Globalization of Applied Scientific Research and Development Requirements*

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Abstract

This paper addresses issues related to competition and scientific research set in a structure comprising the state, scientific research institutions and the private sector. The study looks at the impact of globalization on the role of the state in political decision-making, development of the constitutional and legislative framework for scientific research and technology transfer, the training of technical cadres, and in the setting of research and development priorities. The paper also deals with the impact of globalization on the managerial role of scientific institutions in launching scientific research and technology transfer on the basis of the political decisions and within the constitutional and legislative framework, relying on and developing the technical cadres, and proposing support structures and appropriate legislation to help speed up the process and overcome any obstacles. Finally, the paper explains the role of the local and international private sector in providing material and moral support to the research institutions, and proposing areas of research that are of interest.

I. Introduction

Scientific developments have shaped the world over the last hundred years. However, for scientific research and technology to thrive, there needs to be an availability of skills, an adequate infrastructure, an appropriate legal framework, an effective institutional system, a wise and experienced scientific administration, supporting political decisions, and a society that believes in science and technology. In industrialized countries, 2 to 2.5% of the GNP (Gross National Product) is allocated to research and development, although the percentage of the educational budget allocated to research and basic sciences in northern countries varies from between 4 to 10%, with a similar amount allocated to applied scientific research. In addition, twice this amount is allocated to development and advanced technology.

Scientific research requires both an appropriate environment and a critical number of trained scientists to enable the process of interaction to start. The scientific community then becomes self-interactive, and if it is not well preserved institutionally, it may wither and fade. It is necessary, therefore, to raise awareness within society on the importance of allocating adequate levels of expenditure to different scientific fields, especially in sciences leading to economic growth.

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Indeed, skills and capital are two inextricably linked factors in attaining sustainable growth in a country. The British experience has shown that it is possible to achieve such growth, the Japanese experience has shown that technology is easy to acquire, the Russian experience has shown that giving priority to heavy industry accelerates growth and the Chinese experience has shown that cheap labour is equivalent to capital itself.

II. The Objectives of Scientific Research

Scientific research plays an important role in the creation, development and transfer of technology. Countries need to manage and direct scientific research and technical development to ensure that the human, financial and organizational components are dealt with in order to pave the way for increased rates of social and economic growth. Based on the above, the objectives of scientific research can be defined as follows (Al Safadi & others, 2006):

"Research is the full and direct reflection on the accumulation of human thought and scientific knowledge. It uses methodological means in order to provide qualitative and innovative cognitive products that will have a positive impact, either direct or indirect, which generates an added value in one aspect or more of human activity (economy, social life, administration, politics, etc.)".

However, challenges present in the third millennium often influence scientific research to an extent that exceeds this definition. It has become impossible to work in the field of research or development without taking into consideration the international scientific community. This has transformed scientific research into an organized industry, with the aim to guarantee rapid achievements and to keep the research process on a safe and competitive track, both in the short and long term.

If we take into account the current weak economic, scientific and technical capacities in developing countries, we notice that these countries have to abide by internationally fixed standards on aspects such as product quality and exchangeable services, without having participated in the definition of these standards. Furthermore, the regulations for trade, imports and exports have opened the door to fierce competition. Moreover, international teams impose certain topics on the research and development system. These include areas such as the environmental risks of industrial activities. Working individually in the field of research and development, remote from the international scientific teams, will hold back the local research system and will lead to it being isolated from the rest of the world. Therefore, it is possible to change the research objectives as follows:

"Research is the full and direct reflection on the accumulation of human thought and scientific knowledge. It uses methodological means in order to achieve three objectives:

- To satisfy the human thirst for knowledge.
- To gain new knowledge that has a positive impact and an added value in one aspect or more of human activity.
- To secure the capacity to be present in the international scientific climate and to compete in it."

III. The Influence of Globalization on Higher Education

It seems logical to start with a brief overview of globalization's influence on higher education, before tackling the issue of scientific research. Globalization is defined as the intensified, accelerated and expanded increase in international interactions and links. It leads to one single

world, governed by a single system and a single culture. Frontiers are then also abolished.
Globalization's effect on higher education can be defined as follows (Friwan, 2008): international academic cooperation, international academic mobility, the development of international programs and activities, use of modern techniques in higher education programs, openness to other countries and its influence on the Arab identity.
This influence can be even clearer through the following aspects (Abdel Razik, 2008): the creation of technical universities, the use of techniques in the educational process, development of educational programs in compliance with modern imperatives, modernization of educational tools and methods, quality of educational outcomes and compliance with the needs of the labour market, multi-disciplinary specializations, development of students and faculty culture, modernization of the educational administration, the use of internet among circles of students, staff and faculty, communication with local and foreign universities, orientation towards functional teaching, linking scientific research to the needs of society in order for the university to play a productive role in helping to resolve local social problems, and orienting the universities' work towards creation and invention so as to assist society in producing appropriate techniques.

IV. The Role of the State in the Development of Scientific Research

1. The role of the state in improving the economic environment of the science and technology system

a. Providing stable economic conditions and encouraging investment through adoption of a clear economic vision

Encouraging investments in science, technology and innovation is mainly the state's role, through the establishment of a clear strategic economic vision. This can happen by orienting of economic activity to local and international markets with high purchasing power. Increasing the competitiveness of its products requires it to improve its scientific research and development capabilities and to increase the use of technology.
Such policies will build trust and improve the investment climate of the country, thereby allowing it to compete with other countries. This, in turn, will lead to increased investments in various sectors, which will ultimately increase demand for science, technology and innovation, and lead to higher investments in this field.

b. The adoption of innovative policies to encourage exports and allow the participation of the private sector:

Adopting the concept of cooperative research, which is applied in a number of industrialized countries, will lead to an effective combination between productive institutions, universities and research centres. Scientific experts in these institutions will have to unify their efforts and put their differences aside. It involves:

- Technological research that is attractive to producers and to experts
- Short and medium term research
- Research and information
- Education based on training and education based on technical skills
- Improving basic knowledge and commercialization of new technology

c. The activation of supporting services aimed at improving test level and quality assurance

The specifications, standards and calibration in centres of technology, play a role in promoting technical progress and contribute to improving productivity and quality. The main functions of specifications, standards and calibration are identification and measurement. With globalization and free trade, these functions have to be expanded to include the following:

The increased demand for standardization following the technological boom

The delivery of quality certificates that goes beyond the physical and chemistry conditions of the products to include other conditions such as the products', production, transfer and storage are taking place.

The development of technological instruments for measuring and testing.

The examination and analysis procedures related to quality control of the product and its compliance with international quality standards

The creation of new ways of testing, in order to verify and implement new standards and referential checklists.

d. The stimulation of production in research and development and of the demand on its outputs:

The impact of research and development on economic competition can be measured by the capacity to produce more with less labour. Employment is directly linked to activity and competition levels: any activity that excludes competition doesn't grow, and the main instruments of this growth are research and development.

The promotion of economic skills depends directly on investments in innovations that help to improve technology and increase capacity. Innovations also increase yields in all kinds of other investments, including education. Knowledge gains an economic importance through investments in new technology that allows the promotion of economic competition and an increase in growth and employment rates and, indeed, labour productivity growth rates is the best way to measure the repercussions of innovations. This all points to the need for universities, research centres and productive enterprises to cooperate.

2. The role of the state in providing the primary components of the science and technology system

a. The building of infrastructure

Laboratories for basic sciences: Scientific research falls under the two main categories of basic research and applied research. Basic research aims at understanding the reason for things, their interconnections and their essence, while applied research aims at achieving products and producing outcomes. Assuming that research and development centres can be affiliated to companies and production centres and institutions, basic research can be only a state-sponsored public responsibility.

Specialized research centres: Development often requires the establishment of specialized research centres. For example, the study of arid lands and their vegetation can only be conducted by the state, perhaps in cooperation with other states suffering from the same problem. The same goes for environmental issues, such as the pollution of groundwater, that are, by nature, regional resources. These centres mainly conduct applied research related to vital issues that cannot be ignored. This is not always the case in basic research centres.

Databases: The first prerequisite of scientific research is information. This information is available in databases that provide the necessary information for scientific research. Statistical data can be useful in various types of research, such as in the fields of health, society and products. What we call "cognitive information" facilitates familiarization with a certain subject and with its latest updates. The latter information is similar to a structured, indexed, encyclopaedic work that can be composed of different indexed topic, in different languages.

Communication: The communication revolution at the end of the twentieth century, launched a new era of communication and information. The Internet has many objectives, namely:

- Communicating with members of the work team, other laboratories or potential partners
- Having fast access to information: concerned with activities, conferences, research, brochures of other research centres and scientific journals
- Publishing research activities of groups
- Connecting with a university or research centres' networks

Libraries: The content of libraries, whether books or journals, in hard or soft copy, constitutes one of the main pillars of scientific research. Not so long ago, libraries only offered books and magazines, but the technological progress of the last three decades has made many electronic books to be made available on-line. This allows small countries to access the content of a large number of international libraries by only paying a subscription fee.

b. Qualification and training

Staff training: The lack of specializations is compensated by various academic visits to other countries where the different specializations are available. This enables people to become a critical research mass that can promote a certain specialization and contribute to its development.

The quality of education and its importance in addressing technology and innovation: Between the nineteenth and the middle of the twentieth centuries, the entire economy depended on energy (labour) and capital. This dependency started changing during the second half of the twentieth century. Knowledge and information substituted energy and labour as vital resources for generating wealth. Therefore, if we were to divide real capital into two main categories, the material/concrete capital and the soft capital (cognitive) we would find that the share of cognitive capital is rapidly increasing in most developed countries at the expenses of material capital.

What is needed is to provide learning opportunities, while working on promoting the quality of education. This is in order to enhance the capacity of students to access knowledge and put it to good use, adopt a global approach rather than a fragmented one, focus on abstract concepts, promote academic, cooperative work, break the boundaries of time and space, and meet the increasing demand for various scientific and technological fields.

Training: Training may not directly fall under the theme of scientific research, but it does contribute to assimilating the new technology, which in turn, contributes to scientific research. The best example is training in information and communication technology. Moreover, building the capacities of workers in the industrial sector will increase the demand in industry for scientific research. Developed countries take the initiative in training their working force and the state can either have a direct role in the training, or a supporting indirect role. These roles include lowering taxes for companies that provide training programs for their workers.

Consciousness and promotion: Scientific research requires the involvement of people ready to dedicate their lives to this career. Thus there is need to raise consciousness among students and direct them towards a specialization relevant to development. However, in many developed countries such as Britain, students are not eager to orient themselves towards specializations like physics or chemistry and this can lead to problems.

3. Diversifying the sources of expenditure on research and development through collaborative research and tax incentives

a. The allocation of a percentage of the GDP

According to the UN statistics, between 1996 and 2002 scientific research was not a priority for universities. The statistics are summarized in table 1 which shows that Arab countries devote very low percentage of GDP allocated to research expenditure. Quite apart from the negative effects that weak scientific research has on the economy, the main affect is on higher education which is one of the key factors for generating development. What is needed is for countries to allocate at least 1% of GDP for scientific research expenditure.

Table 1: Percentage of GDP allocated to research expenditure in some industrial and Arab countries (United Nations, 2000)

USA, Japan, Sweden	Industrialized countries, except the previously mentioned	Least developed European countries	Global average	Israel	Arab countries
3.1	2.4	0.9	0.7	2.6	0.2

b. Lowering taxes for the facilitators contributing to financing research

The state can exempt companies from taxes, fully or partially, if these companies invest in research and direct these investments towards local research institutions such as universities and research centres. This measure helps to activate applied research in universities while contributing to the development of the work and outcomes of the companies. This measure is very common in developed countries, but it requires appropriate legislation.

4. The role of the state in enacting the necessary legislation to activate a science and technology system

One cannot underestimate the influence of legislation and financial initiatives on the promotion of education, technology, science and innovation.

a. Protection of intellectual property

Weaknesses in national legislation regarding intellectual property rights, drives companies away from financing knowledge production and this has local and international consequences. Therefore, there is an urgent need to create regulatory frameworks to protect intellectual property and to help expand knowledge based on science, technology and innovation. This framework will also help to promote economic growth, which will inevitably lead to more expenditure in these fields.

b. Regulation of e-trade

E-trade has recently been flourishing as a result of the digital revolution that has transformed the world into a “global village”. This expansion has prompted countries to pass legislation to regulate this kind of trade.

5. The role of the state in designing national policies for science and technology and in preparing implementation strategies

The creation of a national innovation system can only be achieved through a national policy for science, technology and innovation. This policy has to be adopted in the light of a thorough analysis of the current situation in these areas and of predictions for the future. Following this, the preparation of implementation plans and strategies is required.

A national policy for science, technology and innovation includes the following main tasks:

- Coordinating and linking the different sectors related to science, technology and

innovation.
- Defining the priorities of science and technology and allocating the necessary resources (mainly from the public budget).
- Impose regulations on scientific and technological activity.

The analysis of the current situation of science, technology and innovation is the first step to take. The analytical approach allows determining the strengths and weaknesses of the science and technology system, its relation to its environment, the main challenges it has to face and the opportunities it can seize.

Future predictions are based on qualitative and quantitative indicators. They consist of predicting consequences of complementary policies and choices in the long term perspective. In this context, it is possible to adopt the "scenario" method that consists in a series of hypotheses linking between the current situation and the future.

Preparing the strategies (i.e. mobilizing capacities and energy in order to achieve the objectives of a policy) is the stage that links the planning and implementation, but also between the science and technology system and the development planning. Reaching the objectives of the national policy depends on preparing of strategies that include strategic goals, alternatives, standards, regulations, choices and tactics related to the achievement of the objectives.

The implementation plan is based on programs, projects and initiatives and is linked to the five-year development plan of the state. Developing countries often work on designing policies without creating implementing mechanisms. The right thing to do would be to devote particular importance to the implementation stage that is based on the current situation and on international experiences and a sound theoretical background.

V. The Institutions and Components of Scientific Research

We can consider the system of research, development and innovation as a subsystem of the state's systems, in the knowledge that the state itself is, in turn, a subsystem of the international system. We can also note that the information revolution has allowed the existence of direct relations between countries in a way that overcomes national frontiers. Therefore, this system has two environments: the close environment, in the country, and the remote environment, being the international environment (cross-national).

The close environment is comprised of national organizations that do not directly work on scientific and cognitive accumulation, but have a spoken or unspoken need for cognitive or physical goods that result from work in this scientific accumulation. This domain includes almost all the activities of a society, such as industry, agriculture, tourism, trade and services. In all these sectors, there are questions to be answered and needs to be met. This can only be done through the direct investment in scientific and cognitive accumulation. Furthermore, the close environment does not end with physical infrastructure, but also includes logical infrastructures from the cultural, juridical, administrative and financial systems, as well as the means to access information, check its reliability and accuracy and the possibility of investing it.

The remote environment exists in research, development and innovation organizations in other countries, and also in multinational regional or international organizations. This environment does not raise questions for our national organizations to answer. The interactive relation with this environment lies in the capacity to benefit from its accumulation of knowledge, information, skills and experiences. This is on two main levels: the first level involves cognitive accumulation, and it is the duty of national systems to absorb this scientific progress and to nationalize its

products; the second level is the level of the system itself. Developed countries started creating these systems very early and have therefore gained a lot of experience when it comes to the system's role, the best ways to improve its efficiency and facilitate its integration in the global national mission as well as the capacity to invest its outcomes in social promotion and development.
We can define the following components of the research system:

1. Higher studies and doctoral schools

It is recognized that postgraduate research (especially doctoral research) is the cornerstone of scientific research, especially in universities (higher education students are the unknown soldiers of scientific research) and in scientific research centres. The nationalization of these types of research requires a quality leap in the external scholarship policies, summarized in the following areas:

- Developing non-research master's scholarship at the national level so that MA students will not be sent abroad except in necessary cases.
- The adoption of a joint supervision system, in order to prevent dropouts, the nationalization of research, the establishment of laboratories, the building of academic skills, the transfer of knowledge and methods through short term stays in foreign laboratories. It is possible to do so through the signing of bilateral memorandums of understanding that define the role of both parties and the names of the supervisors. These memorandums also have to include the research requirements and the duration of the student's stay in the laboratories.
- The promotion of postgraduate research: with some exceptions, the number of students enrolled in higher education programs in Arab universities is still very low in comparison with other countries.

2. Foreign relations of cooperation

When we talk about foreign scientific cooperation, we mean more than the traditional cooperation methods. It should involve the sending of staff to conduct postgraduate studies such as masters or PhDs, enabling professors to visit research institutions (for a few months or a year), allowing technicians to train on new equipment and technology, and the purchase and installation of new equipment.
Despite the importance of these methods in training staff, building human capacities and preparing an adequate infrastructure for research and development, experience has clearly shown that they are insufficient to conduct serious research activities and to constitute a basis for scientific research. The objective of scientific cooperation is the adaptation of scientific research methods to the national framework and introducing new technologies and working methods that can interact with and develop the local environment. Therefore, it is very important to focus on undertaking local research and technical activities through foreign cooperation, by using the locally available equipment and by benefiting from local capacities, in order to link these activities to local requirements. The familiarization visits that researchers undertake are very important, but it is even more important to recruit foreign specialized experts to help develop the local activities. This requires a clear definition of local needs and the mobilization of sufficient financial resources to encourage foreign researchers to work in local research institutions.
Bilateral relations, such as the twinning of two institutions (or more) that have the same working methods, help to meet specific needs. They also enable activities to be undertaken in both institutions and they facilitate coordination. However, the main problem remains the financing

and implementation of these relations.
The existence of regional blocs, like the European Union, encourages another kind of scientific cooperation, i.e. multi-lateral projects. The European Union realized that such projects were important to enable member states to develop a scientific and technological capacity that could compete at the international level, especially with the United States and the Asian bloc. Member states of the European Union aim to establish a European research zone. The framework of research and development in European countries involves frame programs that define and finance joint research projects involving institutions from various countries. Very often, a minimum of three states has to be involved in the project. The participation of non-European countries in this project is possible and some states even work on expanding this participation, with the exception of certain domains. The participation of local institutions in these projects increases contact with foreign institutions. However it is important that the work of these institutions' is not restricted to statistics, field studies and technology promotion. It is vital for local institutions to participate in the scientific research activities.

VI. The Administration of Scientific Research

1. The mechanisms for marketing the outcomes of research

Market research can be accomplished in many ways such as publishing in local, Arab and international scientific journals, publishing information through local media, scientific reports and advisory and technical publications, organizing forums and conferences at local, Arab and international levels, and providing policymakers and key facilitators (private and government) with appropriate information on research outcomes.
During the past twenty years (Arab Human Development Report, 2002), the number of research papers published in the international press in the field of technology increased by 34,594 between 1990 and 1995. The biggest increase in absolute numbers was registered in Egypt and Saudi Arabia where 84% of research papers of the Arab region were published. Lebanon is the only country in the region where publications diminished (by 500 publications between 1990 and 1995). The number of citations from these published papers was also very small. According to the last Arab Human Development Report in 2002, only four research papers were published in the Arab region which were cited more that forty times. These figures are very low in comparison with papers published in the United States.

2. Links between research and teaching

We can answer some of the questions concerning the link between research and teaching as follows (Zubrick & Rossiter, 2001):

a. A strong link between research and teaching will help universities to be more relevant to an information-based economy. Universities are in competition at the international level, which requires them to prepare students for a competitive labour market. In the long term, governments will support and promote research that can be beneficial for their economies.
b. A strong link between research and teaching reinforces both fields. Indeed, researchers and policymakers in higher education give great importance to academic teaching for two main reasons: first, the importance that the public gives to the quality and credibility of higher education; second, the importance of educating students and building their capacities.

c. The emphasis on academic research will allow universities to get closer to their important clients in industry and society which will help them to get the financial and moral help they need. Moreover, universities that give great importance to research are more attractive to scientific experts, more competitive with regard to student enrolments and more attractive for non-governmental capital.
d. Strong links between research and teaching will promote the quality of research and will enrich dialogue and exchange between academics, students, industry, scientific communities and other beneficiaries. Indeed, applied research that is tied to industry, plays a very important role in the fields of research and teaching.
e. Such strong link is beneficial to the students and to the members of the educational body in matters of teaching performance. The student has to acquire certain ways of thinking and the capacity to assess and build knowledge. All this requires serious efforts regarding the reorganization of teaching and education to ensure that the outcomes are consistent with the desired model.

3. Management of knowledge technology and the current mechanisms

Globalization and economic mergers are bringing many changes in the field of knowledge and technology transfer. In addition, the world trade organization is reorganizing trade.

The transfer of knowledge is useless unless it is accompanied by adoption processes at the national level. This process can be summarized in one term: acquisition of technology. Technology transfer has always been considered in the Arab world as the industrial transfer (means of production) of one product or more and organizing training on its use. In addition, package involves the commercializing of its products according to a legal license that contains a list of practices concerning the changes in the production process, and the available markets and the resources used.

The assimilation of technology can only be achieved when local experts understand the processes of production and the specifications of the material used, and have the capacity to develop it. It is also vital for the producer to use generated technology to develop innovative products that can be competitive on the international stage.

Thus, we can say that the management of knowledge and technology is based on the following patterns:

- The transfer of technology involves acquiring, experimenting and using technology.
- The management of technology assimilation involves the unbundling of technology, the adaptation of technology to the local environment and to the sustainable development process.
- The management of generating technology involves technological research and development, the management of a national innovation system, patents and intellectual property rights, generating pilot companies and financing technology.

The models of technological transfer are numerous. Some of the main ones are industrial licenses, strategic alliances, technical assistance contracts, conventions for patents and the use of trademarks, foreign direct investments, training and administrative and supervisory services, and the right to knowledge agreement.

In the context of technology transfer, two new patterns have recently emerged:

- An exponential increase of direct foreign investments and an increase in the services' share of these investments. When the technology is highly complex or confidential, big companies prefer this technological pattern since it allows the transfer to remain in the company even when it is located in foreign countries.

- The decrease of the "Client Freedom" in technology transfer. For example in the selling of knowledge, licenses or trademarks and the attempt to integrate new determinants to the concession contracts, such as the delimitation of the selling zone, the determination of the sources of supply, the limitation of the market size or number of clients, contracts included in contracts, i.e. the selling of technology rights.

VII. The Development of Human Resources

The main mechanisms related to the management of human resources (Al Masry & others, 2006) in any scientific research institution are attracting human resources, planning human resources, vocational guidance and applying the predictive administrative method to human resources.

1. Ways to develop human resources

1) Increase the number of researchers according to development requirements.
2) Improving scientific skills, organizing and developing the working methods of researchers and their assistants.
3) Preparing and training the necessary staff with adequate quality standards.
4) Regularly revising the manpower distribution among administrative and scientific posts.
5) Addressing the problem of "the brain drain" and encouraging the return of "migrating" brains.
6) Providing researchers with the necessary working tools through modernization, establishment of laboratories and modern technological equipment.
7) Providing sufficient financial resources for human resources and research imperatives.
8) Developing the organizational and administrative infrastructure in all scientific institutions and guaranteeing the use of modern technology in their activities.
9) Promoting human resources management, motivating employees and efficiently evaluating their performance.
10) Improving the legislative and legal environment in order to develop scientific institutions and guarantee their independence.
11) Increasing the number of workers in scientific research and development and enhancing their capacities.
12) Creating and consolidating coordination ties between researchers and their foreign colleagues.
13) Creating and consolidating ties between research institutions and economic institutions.
14) Guaranteeing access to sources of information through modern technology, namely through the Internet, which is considered as a vital source of information and communication tool between researchers and scientific and economic institutions.
15) Improving the publishing of research according to economic and development needs.
16) Improving the economic, political, social and cultural state of affairs.

2. The imperatives of human resources (HR) development

1) In order to conduct any scientific research, it is necessary to take the following measures: define the financing party, define an expenditure mechanism, avoid reliance on a centralized authority in decisions concerning daily and urgent financing needs, define the financial share of researchers and other participants in the project (e.g. researchers,

engineers, technicians), and facilitate the direct purchase of the required equipment without having to consult the university administration or research centre.

2) Creating a fund for supporting scientific research, technological development and innovation. This fund could be financed by the state, the private sector, or Arab, Islamic or international organizations.
3) Encouraging the public sector institutions to finance projects in scientific research and technological development in their sphere of interest. These institutions can help to define these projects so that they can gain direct benefit from their outcomes.
4) Encourage applied research with material benefits.
5) Establishing a human resources incentives system which includes four aspects: material positive incentives for the distinguished, material negative incentives for non achievers, moral positive incentives for the distinguished, moral negative incentives for non achievers
6) Adopting a predictive HR management system in scientific and research institutions.
7) Benefiting from researchers according to specialization, qualification and experience.
8) Defining the national development program and publicising it to open-op discussions with all stakeholders in order to determine the available resources, including financial, and the necessary cadre and their preparation.
9) Developing higher education with a precise implementation plan defined by the facilitators in the fields of education, research, development and innovation, as well as those in economic and social development (from both the private and public sectors).
10) Developing research and development institutions, providing them with specialized experts, granting them a large margin of independence and all the necessary resources.
11) Assigning every university, faculty and educational institution the task of forming a committee to monitor their human and financial resources. This committee would present relevant reports in order to build a database to help in coordinating and planning efforts.
12) Assigning every university, faculty and educational institution with the task of submitting a precise developmental plan. The plan should clarify needs in terms of training, projects, equipment and organizational structure. The plan should be developed in cooperation with private and public economic institutions and international and Arab organizations.
13) Reducing time-consuming, complex bureaucratic and administrative procedures which constitute obstacles to the researchers' work. It is also necessary to adopt flexible administrative procedures in scientific institutions.
14) Developing a new administrative policy for researchers, in compliance with the nature of their work. Indeed, researchers tend to be very independent in their work; they do not react well to restrictions, procedural organization and strict audit.
15) Selecting researchers among the most engaged and distinguished.
16) Recognising the importance of engagement and self-motivation for researchers in order to reach exceptional and innovative outcomes. Thus, it is necessary to encourage researchers and avoid framing their work in a rigid, predetermined way.
17) Guaranteeing appropriate working conditions for researchers, such as good office space and information and communication tools.
18) Building local, Arab and international networks between researchers who have similar or complementary specializations, in order to encourage collaboration.
19) The institution should not rely solely on its internal staff but, when appropriate, seek

external expertise and consult other institutions in helping to solve particular issues.

20) Choosing the most promising students and directing them towards research centres and higher institutes. Sending some students to developed countries in order for them to pursue their education.
21) Focusing on the importance of science and knowledge. Giving students a thirst for knowledge and education, stimulating their curiosity and encouraging them to consult books and references.
22) Determining policies for internal and external educational scholarship programmes, in compliance with cooperation agreements.
23) Introducing disciplines in methodologies of thinking and innovation and communication skills in schools and universities.
24) Focusing on preparing and training experts in scientific research through creating a permanent training department in all faculties and research institutions. Recruiting foreign experts for short training seminars.
25) Providing scientific publications and periodicals as well as travelling to participate in conferences and conferences. Following participation in these seminars, experiences need to be shared with the research community to ensure that local research reflect international research practices and activities.
26) Determining masters and PhDs themes and topics in universities and research centres, according to the needs of social and economic institutions.
27) Facilitating financial procedures for recruiting foreign professors to deliver lectures and supervise doctoral research.
28) Creating an office for sponsoring inventors and innovators.
29) Supporting and developing an exhibit of inventions and innovations. Reviewing the selection of exhibits to check their quality and scientific reliability. Ensuring a high level of media coverage and increasing the value of awards.
30) Creating a website in every scientific institution with a brief overview of the institution's identity, its goals, staff, and its current and future activities.
31) Benefiting from cooperative programs with the European Union. Cooperating with developed countries in common research and in technology transfer.
32) Inaugurating a scientific museum, organizing scientific exhibitions with the aim of attracting students and citizens and emphasizing the importance of science. Calling upon private and public institutions to provide financial support.
33) Encouraging teamwork and cooperating in order to achieve the assigned goals.

VIII. Performance Indicators and Standards to Evaluate the Scientific Research System and its Accomplishments

The system of research, development and innovation needs standards and measuring indexes to evaluate its performance. These standards can be categorized as follows:

- Performance standards of scientific institutions
- Performance standards of scientific experts working in these institutions
- Standards linking the outcomes of the institutions' activities to aspect of development.

All these measurable standards can evaluate the performance of the system. Indeed they all reflect the actual efficiency of the system's work mechanisms and outcomes and these two factors are essential for an accurate evaluation. The standards that can be adopted to evaluate the system's performance can be outlined as follows:

1. Evaluation Standards of the system's outcomes

This is a list of standards that reflect the direct scientific or practical results of the system's work:

a. Scientific referred publications acknowledged in scientific records and international conferences
b. The number of patents delivered and the numbers of patents that were actually invested in
c. Higher scientific degrees granted in the context of the scientific research activities undertaken in the system's institutions
d. The number of job opportunities created by the system's affiliated institutions as a result of research-oriented activities
e. Contracts concluded between research institutes and the productive sector as well as the size of the funding provided by these contracts
f. The system's goods and products that promote self-sufficiency, even if they are currently available
g. The improvement of human health and environment
h. The number of generated technological poles or incubators related to the system's activities

2. Standards evaluating the system's work mechanisms

This is a list of standards evaluating some important aspects of inputs and work mechanisms and that affect global performance:

a. Scientific cooperation agreements that link the different institutions of the system
b. Scientific cooperation agreements that link the system's institutions to external facilitators
c. The size and source of the system's funding
d. The size of expenditure allocated to research and development in the system's productive institutions.

3. Other standards that indirectly reflect the system's success and development

This is a list of standards reflecting the system's scientific reliability, its capacity to host highly qualified scientific experts and its capacity to interact with similar regional and international systems:

a. The number of award-winning experts working in the system's institutions
b. The increase in the number of people working in the scientific research institutions during a specific period of time, and improvements in their qualifications
c. A series of standards evaluating the possibility of linking the national research and development system to regional and international systems. These standards include joint research projects aimed at producing an investable product, the number of local researchers participating in joint research conducted in foreign laboratories, the number of hosted researchers involved in joint research and the number of national hosting laboratories.

IX - The Role of Mediating and Supporting Institutions

The contribution of institutions in offering mediation services and the support that the private sector provides to scientific research and technological development helps to bolster economic growth and to improve and diversify productivity.

One of the biggest challenges that face applied scientific research in Arab countries is the lack of private sector contribution in enhancing, modernizing and financing scientific research. According to the World Economic Development Report, in 2006 private institutions spent approximately 12.6 million dollars to finance scientific research in all Arab countries i.e. only 2.9% of total research and development expenses, whereas state budgets allocated 48.9 million dollars (61.5%) and universities paid 217.3 million dollars (27.8%).

Table 2: Scientific Research Sources of Financing in Arab Countries (United Nations, 2005)

Expenses in Percentage Terms	Expenses in Numbers (million dollars)	Source of Financing
61.5%	840.9	State Budgets
27.8%	217.3	Universities Budgets
2.9%	12.6	Private Sector
7.8%	61.5	External Financing
100%	782.3	Total

1. Importance and role of mediation and supporting institutions in socioeconomic development

The private sector and the institutions that provide mediation services and support contribute to development plans, given that they play an important role in using local resources to enlarge and diversify national revenue sources, expand productivity and increase the Gross Domestic Product (GDP). Consequently, new objectives, plans and strategies must be defined so that governments devote a bigger role to the institutions that provide mediation services and support, whether through financing or through establishing research centres and incubators that support scientific research and technological development. As a result, the following measures are needed:

a. Increase the contribution of private sector institutions in mediating and supporting socio-economic development
b. Define ways to reach this policy
c. Implement the policy

The private sector (along with the mediating institutions) plays a major role in achieving these objectives through providing permanent support to scientific research. This support can be provided by chambers of commerce and industry and relevant councils that represent the private sector. These chambers have to support scientific research activities in all domains, such as (Shaaban, 2008):

1) Developing strong partnerships with local and international institutions with the aim of improving private sector activities
2) Monitoring the performance of Small and Medium Enterprises (SME) to draw conclusions that help enhance their efficiency
3) Setting integrated networks of information and statistics about market needs in terms of scientific research

4) Outlining the private sector market's detailed needs and requirements
5) Specifying investment opportunities suitable for research
6) Presenting the viewpoints of businessmen in all sectors that support scientific research
7) Enabling scientific research centres to give advice on financial, economic and organizational problems
8) Raising all important local and international issues related to research during forums and conferences related to the research process
9) Preparing annual reports, statements and analytical indicators for companies financing scientific research centres
10) Building a favourable investment environment to attract local and foreign investments
11) Making scientific research results public so that the private sector can benefit from them
12) Encouraging the private sector to establish independent university-affiliated centres and institutes for research and development
13) Building cooperation bridges with scientific research institutions all over the world
14) Signing scientific cooperation agreements with universities and integrate research

2. Obstacles preventing the mediating and supporting institutions from effectively playing their role in developing scientific research

Institutions that provide mediation services and support face many obstacles such as (Turkmani, 2006):

- The absence of chambers of commerce, industry and agriculture in terms of developing cooperation between universities and research centres
- Weak communication channels between mediating and supporting institutions and scientific research institutions
- Low interest in the problems and requirements of productive sectors
- Poor spending on scientific studies aimed at developing enterprises
- The gap between industrial sectors and scientific research institutions
- The absence of coordination and cooperation within similar industrial projects in a single industrial sector

3. The big issues at stake in science and technology

The lack of water resources is the biggest issue facing Arab countries in the 21st century. According to a study undertaken by the World Water Organization (Journal of Water Resources Development, 1999) one third of the global population i.e. 2.7 billion people will face an acute lack of drinking water by 2025.

The major challenge facing developed countries is improving water resources management to assure its sustainability and quality, whilst meeting all the needs without harming the ecosystem. With this end in view, scientific and technological capacities are being mobilized and improved methods are being developed for the global management and the sustainable exploitation of water resources. Studies are being undertaken concerning the climatic characteristics of humid zones and freshwater ecosystems. New techniques are being put in place for water filtering and treatment, as well as new water protection methods and early warning systems for on natural disasters. Desalination techniques are being developed from two integrated aspects - technical and economic - and efforts are being deployed to build plants that can be easily used and

maintained, and are economical and environmentally friendly.
In terms of the environment (SIBIS, 2001), Earth's situation is not much better than that described for water due to the increase in toxic greenhouse gases in the atmosphere, nuclear waste storage, risks of nuclear proliferation (due to civil nuclear uses) and desertification in the south. Industrial countries are mainly to blame for this situation, but by 2020, the south will imitate northern models, as rising consumption will lead to higher oil production and thus to more greenhouse emissions.
Taking up these environmental challenges requires more scientific discoveries to develop wind and solar energy that can be used in the future. Scientific research is increasingly focusing on improving the efficiency of bioreactors that provide many solutions. For example, in water recycling, researchers are working on genetically modified components that can absorb polluting materials. This initiative could lead to significant developments in combating water pollution and oil spills. This breakthrough could also be used to enable polluted soils to recover their arability.
In terms of agriculture and nutrition (World Summit on the Information Society, 2003), scientific and technological progress will lead to a revolution, as more plants and animals genomes will be unveiled, especially the genomes of insects, making them easier to control. This progress will also help create additional and new micro-organisms for plants and animals, as well as new management systems, to guarantee soil renewal. As a result, farmers can adopt developed techniques that take into consideration the climate, soil treatment and plant selection. They can also use a manufactured tailor-made soil that guarantees soil renewal and protects greenhouse plants and those growing naturally.
Genetic modification of plants (Bizri, 2002) will pave the way for the diversification of food and less animal protein on the plates of the developed world's population. New healthy, ecological and ethical procedures will shed light on the importance of the vegetarian diet. New types of genetically modified food will be available according to the consumers' tastes, nutritional needs and health. Nutritional concerns (preserving food, developing new types and improving existing ones) fall within the scope of many fields, such as physics, chemistry, biology, engineering and industrial management.
In terms of health (European Trend Chart on Innovation, 2005), a deeper understanding of human genetics will pave the way for new methods that will not only be based on prevention, but also on the reinforcement of physical and intellectual capacities. Potential relationships between diseases and disorders will be highlighted as biochemical reactions become better understood, particularly the ones that lead to diseases, disorders and interactions with the environment or due to individual personal history.
Moreover, the physiological, chemical and genetic causes of human behaviour would be unveiled and thus combating diseases and strengthening individuals would become common practice. In addition, new techniques that help control the brain and the way of thinking will be developed and used to control emotions, capacity to learn, senses, memory and other psychological states.
In terms of medicines (ESCWA-UNESCO, 1998), much research is currently being carried out to reuse known drugs for new purposes. For example, the use of vitamin D to combat cancer cell expansion or relieve sound cells that come into contact with exogenous bodies such as contact lenses and inhalers. Moreover several research activities are being undertaken to produce medicines from micro-organisms coming from metabolic reactions, mutations and genetic engineering. Some researchers are also working on developing vaccinations, lotions and serums to strengthen immunity against HIV.
In terms of nanotechnology (World Development Indicators, 2002), developed countries attach

great importance to this science of particles and atoms whose name derives from nanometre i.e. one billionth of a meter. Nanotechnology is based on the study of particles and is not only a revolution in the design and use of equipment, but it also entails many social and economic aspects. Scientists and technicians are eager to develop these techniques which help to measure and evaluate things at the atomic level. I n addition, according to the results of some laboratories, these techniques can be used in different areas such as microelectronics, energy preservation, medicine and engineering. Moreover, nanotechnology is expected to start a revolution in the near future for producing materials and enhancing the capacities of computers and informatics in order to resolve the most difficult issues. These new methods of production would be smarter and in-line with sustainable development and environment protection, given that they produce more with less. Nowadays, nanotechnology generates among scientists, industrialists and bold investors a momentum similar to the interest aroused by biotechnology two decades ago.

X. Conclusions and Recommendations

This essay highlighted first the importance of an integrated triad composed of governments, scientific research institutions and their environment and the researcher. This is the best formula for a successful process. If any of these components is absent, research is a mere personal initiative that does not bring any added value to development and fails to make scientific research one of the state's most important assets and the force behind its productivity. It is, therefore, important to take the following measures:

- Create scientific and technological groupings and clubs for scientists and researchers.
- Promote consciousness of the economic and developmental benefits of science, technology and innovation.
- Establish an Arab scientific news agency responsible for disseminating information about science in Arab countries and international scientific innovations in a variety of languages.
- Launch initiatives that promote national productivity through competitions under the slogan "Made in …"
- Establish within Arab research and development institutions effective offices that disseminate scientific knowledge.
- Develop and improve the Arab environment at the financial, social, academic and legislative levels, especially in terms of intellectual property rights.
- Establish institutions that offer mediation services and innovation centres which match scientific research institutions along with secondary and tertiary sectors to provide research with production possibilities and investment.

Furthermore, this paper considered that it was essential to adopt a medium and long term strategic approach to build a research society, while keeping in mind the importance of international cooperation to raise local research to the level of international research. This process is vital as it lays the foundations of a strong, competitive, productive and innovative scientific community that provides for the needs of its society. In this regard, it is important to take the following measures:

- Enhance inter-Arab scientific cooperation including the cooperation with Arab scientists in the West. .
- Set up networks among universities and research centres in Arab countries through new information technology, in order to follow up the latest developments in science, technology and innovation throughout the world.

- Improve planning and organization of research, development and innovation activities while implementing quality standards.
- Establish centres for scientific and technological restructuration in each Arab country and in the Arab region as a whole, to face the scientific and technological challenges of the 21st century.

This paper considered the main scientific and technological issues relevant for strong partnerships with the private sector and with scientific research institutions all over the world. For this to happen, it is important to take the following measures:

- Launch a joint Arab initiative for biotechnology and relevant ethics.
- Encourage Arab universities and research institutions to use nanotechnology and smart materials.
- Establish desalination plants in Arab countries using new technology and create an advisory council in charge of water affairs.
- Set up an initiative for the peaceful uses of nuclear energy.
- Launch joint Arab projects in renewable energy, especially photovoltaic and solar energy, bio-fuels and biogas.
- Set up an initiative to build ecological centres with Arab and international financing for industrial waste treatment in Arab countries.
- Set up an initiative to create joint Arab specialized centres and research units for issues such as diabetes, heart disease, therapeutic plants, environmental health, metabolic science, health awareness and polio.
- Establish an Arab network in the agricultural sector to enhance the scientific and technical capability of people working in this sector and to combat desertification.
- In general, this paper has shed some light on the different related issues that should be taken into consideration when designing new approaches to scientific research. However, the integration between the local, Arab and international approaches is one of the most important requirements in the development of scientific research in the new era of globalization.

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