# THE BROKEN CYCLE: UNIVERSITIES, RESEARCH AND SOCIETY IN THE ARAB REGION

## PROPOSALS FOR CHANGE

13-0109

## Forward

The underlying relationships and interactions among scientific researchers and universities with their communities in particular with the production and services sectors, represent a critical issue in stimulating research, development and innovation, and in improving the impact on the development of Arab societies. This topic has become fundamental and was highlighted in the multiple reports on human resources development, knowledge and society in the Arab countries. Recently many reports pointed to this fact in different ways, including the Arab Thought Foundation (3rd and 5th report for the year of 2010 and 2012), the United Nations Development Programme, the Economic & Social Commission for Western Asia and Mohammed bin Rashid Al Maktoum Foundation. More recently Dr. Antoine Zahlan addressed this subject matter in his published book entitled "Science and sovereignty: the reality and potential in the Arab countries". In this current report the collaborating institutions seek to update data about the underlying and direct relationship between the academic community and Arab societies, as a complementary for the past initiatives. This would open the door for further discussions and cooperation in order to strengthen this relationship and bring it to the level prevailing in the knowledge based societies.

This report was possible with the support of the National Council for Scientific Research in Lebanon in cooperation with the United Nations ESCWA Technology Centre and other outstanding institutions and researchers who supplied data and objective analysis. We are hoping that this document can serve as an effective step in the right direction to serve the Arab scientific community and to enhance its capabilities and its human and material resources.

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## I. INTRODUCTION

Research and analysis on knowledge production and innovation in the Arab region have grown exponentially in recent years. This is the case not only in those countries that invested in science and technology following independence, but also in relative newcomer countries, particularly from the Gulf region.

Closely linked to this growth, there has been an expanding awareness of the importance of knowledge in society. The excellent recent study published by Antoine Zahlan, a long-time observer of scientific development in the Middle East, titled Science, Development, and Sovereignty in the Arab region not only underscores this general move towards more scientific activities, but also presents a reflection of how and why scientific research should be developed. Zahlan's study, like many official documents that one can now find published by large organisations (whether regional or international), calls for more research and innovation. Usually this is based on a diagnosis of the low intensity of research, and is accompanied by a wish that science and/or innovation will ultimately become a matter of priority for the Arab States.

The present report takes up a similar line of thinking, as its authors are convinced that there is room for the improvement of research and innovation activities. This report adopts a national rather than a regional perspective, with the efforts of each country examined individually. Nevertheless, the dynamic of research and innovation is not only related to national policies and national frontiers. Rather, it is a dynamic dependent on the social actors directly or indirectly involved in the development of scientific activities: individual researchers, research groups, research institutions, universities and institutions of higher education, research communities, enterprises, and public policies enacted by Governments and inter-governmental programmes. These actors work at the global or national level, according to their own needs, perceptions and objectives. Logics of action may thus be different, divergent, or in direct opposition to one another.

Perhaps prematurely, Arab countries have wanted to be called 'knowledge societies' (see the first chapter of the Arab Knowledge Report[1] that stresses the different meanings and visions that the term entails). Every country appears driven by the need to become a 'knowledge economy', a title that became popular following the World Bank report of 1999.[2] Building a knowledge economy became a policy objective alongside, and sometimes in contradiction with the goal of establishing national innovation systems. The concept of a knowledge economy was formulated for developed economies that enjoy a dense network of research institutions, a high degree of investment in research and development (R&D) in both public and private institutions, and a strong infrastructure, known, since the rise of the digital age, as 'knowledge infrastructure'. Curiously enough, the knowledge economy was proposed by the World Bank report[3] mainly based on a comparison of the trends in Asia and Latin America, and under the direction of a bank official based in Mexico City. Probably one of the very first authors to write about the 'knowledge society' was Nico Stehr.[4] He noted that, as a result of the remarkable growth of science and technology in modern society, it had undergone a fundamental shift and become an immediately productive force: no longer was technology a 'cultural' product, but a basic ingredient of any sustainable, long-term economic strategy. The closeness of science and technology that research has uncovered is here to stay, and will run ever deeper in social and political decisions. As scholars from all over the world have shown, a new set of institutional

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[1] Arab Knowledge Report, 2009.

[2] World Bank, 1999.

[3] World Bank, 1999.

[4] Nico Stehr, 1994. Stehr also wrote part of his report in Mexico.

capabilities is everywhere deployed.[5] Yet, beyond glorifying the word 'knowledge', there has been little reflection on these changes in the Arab region.[6]

Simultaneously, since the end of the nineties, the emerging economy has become the concept of the day. At the start of a new century the world appears increasingly multipolar, with 'knowledge' playing many different but vital roles. In the process, developing countries seem to have disappeared from the radar within the new knowledge economy. A new concept was needed for what Alice Amsden rightfully called 'the Rest', in contrast to 'the West'.[7] If 'developing' is no longer the right word for these economies, what is? Have the modes of producing, using and diffusing knowledge changed so much that development itself is an obsolete concept? Are we all living in a 'flat world'[8] without borders, where power structures have disappeared? Whether one views globalization as beneficial or harmful, there is no doubt that it is tightly interconnected with science and technology, as stressed by the Arab Knowledge Report.[9] Multipolarity, indeed, does not indicate the disappearance of hegemony: on the contrary, it is a clear indication that several large centres of research and innovation will exercise hegemony over the field, in a far more aggressive competition than had existed in the divided world of centres and peripheries. Two French sociologists have proposed to call those countries that belong to neither the old centre nor the new emerging economies "non-hegemonic countries".[10]

The notion of a non-hegemonic country relates to two essential dimensions: the position of the country in the international division of scientific work and the fact that these non-hegemonic countries do not have financial instruments capable of influencing the broader goals of knowledge production, unlike the United States, the European Union and a small number of Asian countries. Things are probably different for innovation as opposed to research, since not all innovation is research-based, and since innovation can be more multi-faceted than research. Nonetheless, non-hegemonic countries have usually adopted an incremental development model, based on a game of technological catch-up. The experience of Asian Tigers is precisely one of catching up, learning and adopting technologies that then become key tools of economic development.

### A. STRENGTHENING KNOWLEDGE PRODUCTION, USE AND DISSEMINATION

This report seeks to investigate opportunities for increased research activity and innovation, rejecting the assumption that these processes will come about of their own accord through organic growth of the academic sector or simply increasing entrepreneurial activity.

In effect, as Mouton and Waast (2009) pointed out in a detailed study on medium-sized economies, one can easily distinguish countries that have decided to put emphasis on research and innovation in their development and economic strategies and from those less keen to invest in research and innovation. The authors show that many reason explain this choice, such as historical precedent, the role of the state, the

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5 Valenti, G. et al., eds. 2008. *Instituciones, sociedad del conocimiento y mundo del trabajo*, Mexico: FLACSO Mexico, Plaza y Valdés Editores.

6 Antoine Zahlan, with a different wording, insists on the need to integrate more reflection in the development of knowledge organizations: 'Today the Arab countries could easily mobilize thousands of leading scholars – scientists, engineers, and doctors – to initiate high quality universities. Surprisingly, there are no tendencies toward improving higher education by utilizing national intellectual resources. (…) Scholarship, quality, research, and knowledge are still not prime considerations' (Zahlan 2012, p.165). See Chapter 10, pp. 157-175. On Emiratis knowledge society, see Maghreb-Machrek edited by Dumortier, B., 2008, '*La société de la connaissance dans une perspective arabe*', Maghreb-Machrek, p. 195.

7 Amsden, A.H., 2001, *The Rise of "the Rest". Challenges to the West from Late-Industrializing Economies*, Oxford (UK): Oxford University Press.

8 Friedman, T., 2005. The World Is Flat: A Brief History of the Twenty-first Century. Farrar, Straus and Giroux.

9 Arab Knowledge Report, 2009.

10 Losego and Arvanitis, 2008.

relation of the state to its scientists and to the use of knowledge in the state apparatus, the type of development strategies (and to what extent national development becomes an objective), and trust in science. It also related to how elites view science. Investment in research and innovation is a policy choice, and in non-hegemonic countries, the active decisions of the state influence more profoundly these choices than countries with multiple actors engaged in research and innovation and broader historical commitment to research.

Concerning innovation, the differences are related to the presence of an enabling social and economic environment for companies that wish to introduce new products and processes into the market. The literature on the topic is too often reduced to entrepreneurship; although it is part of the equation, no one should doubt the entrepreneurial capacity of Arab societies. Innovation is a complex process involving investment, organization and technology; and the success of one company does not necessarily translate into positive indicators for the economy as a whole. This makes the argument in favour of scientific policy difficult to sustain since there is no immediate visible effect, one cause producing one effect. But the effort accumulates over time, and innovation is path-dependent, meaning that today's success is based on yesterday's effort.

Understanding path-dependency is particularly important, as new research and innovation activities will always be based informer investments and experiences. The form innovation will take tomorrow is very much based in the technological research engaged in today. Much of the resulting technology will depend upon connections and networks developed in the past; in turn, these will create the enabling environment for the exchange of information and resources needed for innovation. In other words, they create what is usually "cultural" conditions for innovation, which – as the reader has now understood – is anything but cultural: innovation is not the product of any particular culture; it is the product of enabling environments.

Many studies published on the Arab region in recent years have struggled to identify the specific causes of its slow rate of technological catch-up and under-investment in knowledge production. They do so by focusing on the national level and partly that may explain why they have been so unsuccessful in explaining the under-investment.

There are historical reasons for this choice. Since the Second World War, science has been thought of as a national project, and an expression of national sovereignty. This led to the establishment of national institutions closely related to areas of state power. Academic disciplines, areas of technological investment, domains of interests and objects of research were all viewed through a national lens. Scientific collaboration was also seen as an inter-governmental and international activity. This went hand in hand with the creation of national plans for science and technology, and the setting out of national priorities. But in the 21$^{st}$ century, and since the end of the 20$^{th}$ century, as globalization becomes an economic and political norm, this national orientation has come under threat. Areas such as nanotechnology and biotechnology have developed in emerging countries, despite their low investments in other areas. New industries have appeared in emerging economies in the sectors previously reserved to rich and hegemonic economies. These technological breakthroughs have become visible at a global level, and research orientations are defined internationally. Paradoxically, this globalized perspective on research has been constructed at the same time as national innovation systems are being proposed as the reference framework of innovation policies. Thus global research has become a norm alongside national innovation systems.

## B. STRENGTHENING RESEARCH

When tensions arise over science, technology and innovation, countries are involved not as one-state actors in a multilateral negotiation, but inside fragmented controversies (in the sense of Bruno Latour) between actors with global reach. This has been clearly demonstrated with regards to public health issues such as access to anti-retroviral medicines, intellectual property disputes over global technologies, and disputes over the management of local knowledge systems (e.g. in natural products with pharmaceutical action) or biodiversity resources. Fundamental issues including human security, energy, food security, environmental degradation and desertification all demand local solutions that draw on global knowledge resources; and these resources are all developed and accessed through research. Research also plays a key role in international fora, where standards defining legal codes, security, health and trade regulations are debated and established. Membership in the exclusive club of those proposing norms and regulations at the global level is determined by research.

To solve the riddle of under-investment in research and innovation in the Arab region, it is important to keep in mind that the agenda for science and innovation is always political. This agenda affects how knowledge is created, used, and disseminated, a process that is still not well understood in the Arab region.

Moreover, the effort to implement an active research structure requires the development of a common multilateral strategy involving centres in different countries, a topic discussed during the Arab summit in 2010. But this is also a political choice: until now very few countries have been willing to share their resources, even with other Arab States. The various new institutions mentioned by the Arab Knowledge Report have been national endeavours with little multilateral cooperation, although scientific collaboration is the very heart of the scientific activity and is necessary to advancing research and innovation in the region.

To understand how the issues can be turned into a research and innovation agenda, we need to focus on the conditions of knowledge production, dissemination, and use: it is necessary to focus on the nature of existing problems in academic life inside universities and research centres of the region, and to examine how innovation takes place. This is even less understood than public research activities, merely because too few scholars study what effectively happens inside enterprises. Academic life should be understood in a broader sense than simply what goes on at university campuses. It also includes researchers at public and private institutions engaged in scientific innovation. Connecting science to society and applying scientific and engineering knowledge to the economy are not reducible to commercialization or the creation of the right business environment. It is a matter of weaving together the multiple forms of linkages between production and use of knowledge.

This report seeks to present a vision of the future role that scientific research can play in the socio-economic development of the ARAB region, particularly by enhancing the competitiveness of the productive and services sectors. It will discuss how institutions and governments of the region can cooperate to achieve these advances.

## C. STRUCTURE OF THE REPORT

This report analyses the findings of a comprehensive review of national research systems in the Arab region. It aims to contribute to a much-needed discussion on the following subjects:

1. Indicators of the governance and overall performance of the research systems in the Arab region, alongside research funding.

2. Knowledge production and scientific collaboration through publications from several Arab countries.

3. Innovation systems and policies in favour of innovation.

4. The special role of universities.

5. Human capacity and scientific capital, including the challenge of brain drain from Arab countries.

Prior to a discussion of the main findings, a note on the key methodologies is in order.

## D. METHODOLOGY

This report is a meta-review of existing country studies in the Arab region. A meta-review (or systematic review) has both descriptive and evaluative aims:

1. To work through available studies and systematically summarize all possible sources of information (government resources, websites, science and technology (S&T) centres) to identify those that meet the criteria for inclusion.

2 To examine available statistics on the state of science and technology in the Arab region, where there is a need for reliable indicators and evidence-based policy recommendations. This meta-review reports on the types of indicators that have been gathered, then examines the question of data in the region.

3 To produce a summary "map" of those themes deemed of greatest importance, and, at the same time, to produce a non-exhaustive literature review. This scholarly effort seemed important, given that the literature on science and technology research in the Arab region continues to grow.

## II. INDICATORS AND DATA IN THE ARAB SCIENCE SYSTEM

### A. ABSENCE OF INDICATORS

Before describing the research systems and the factors affecting the dynamics of science and technology in the Arab region, the authors explored the indicators commonly available to public scrutiny. The sources here are less numerous. Most of the statistical information has been compiled by the United Nations Educational, Scientific and Cultural Organization (UNESCO)[11] and the Organisation for Economic Co-operation and Development (OECD)[12] and contain data for member States of those organizations. Countries of the Organisation of Islamic Cooperation's Standing Committee on Scientific and Technological Cooperation (COMSTECH)[13] have also gathered data without employing any recognized definition for manpower and financial statistics. All of these organizations rely on reporting by public authorities. While it is understandable that national authorities would provide national statistics, in most countries, the State has not given special interest to science and technology as part of their statistical administration. The information provided has many other shortcomings, as has been noted repeatedly by various researchers and institutions.[14] Thus there is a dearth of reliable data on research and innovation in the Arab region.

After many years of recommendations by all possible international organizations, there are still no reliable inputs, that is, data gathered according to the international standards set out in the "Frascati Manual", a document that contains all the internationally recognized definitions for science and technology statistics. It should be emphasized that these statistical standards have been the product of a professionalization of statistical data on science and technology. Even if they have their own drawbacks,[15] they were designed to respond to the need fora global view of the science and technology and to identify the competitive status of OECD countries. The statistical infrastructure has been created for this specific purpose after the second world war; but most Arab countries have not been involved in this techno-economic competition that affected OECD countries. Thus, they have lacked the incentive to promote statistics of the same nature; a lack that is usually underlined by international organizations, which press them to produce uniform data. In brief, most Arab countries have had the same debate on the necessity and uses of scientific research as OECD countries; but, unlike them, competitiveness was not their main interest. Instead, they tended to focus on consolidating the academic institutions executing research. This capacity building required crude data on the number of professors and students; as a result, more complex questions were left unattended. Thus it appears that Arab countries have not had a strategic understanding of the role of research. The debates on science and technology in society were mainly triggered by international organizations, in particular the 2005 Arab Human Development Report of the United Nations Development Program (UNDP), which stressed the idea that research was hindered in the Arab region because of lack of freedom.[16]

Thus, no reliable statistics exist on research and innovation in the Arab region, and no statistical infrastructures or institutions have been designed to produce them. This can be particularly problematic when attempting to establish international comparisons. This situation is not unique to the Arab region. But, beyond Europe and North America, only Latin America has developed a good network of observatories called the Network for Science and Technology Indicators (RICYT), which receives regular support from

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[11] See UNESCO Institute of Statistics (Montréal). www.uis.unesco.org.

[12] See OECD Directorate of Science, technology and innovation. www.oecd.org/sti/.

[13] COMSTECH is a Ministerial Standing Committee on Scientific and Technological Cooperation established by the Third Summit of the Organization of Islamic Countries (OIC). comstech.org/.

[14] See: ESTIME: Towards science and technology evaluation in the Mediterranean Countries (Final report by R. Arvanitis 2007), p. 80. www.estime.ird.fr. MEDIBTIKAR. EuroMed Innovation and Technology Programme. EU-funded Regional and Communication Project on the European and Mediterranean Partnership (EUROMED). 2010, p. 78.

[15] Godin, 2005.

[16] There were strong debates triggered by the UNDP report on knowledge in the Arab region, UNDP, 2005.

UNESCO. No such network exists in either Asia or Africa, although some organizations like Globelics[17] have promoted linkages between units working for policy-making bodies in technology, innovation and economic development. In the Mediterranean region, because of its strategic importance for the EU, a number of networks have been promoted.[18] Nonetheless, these statistical indicators are available only in those countries that have demonstrated a political interest in science and technology at the national level, which is by itself an indicator of their focus on research and innovation.[19]

### B. SCIENCE AND TECHNOLOGY OBSERVATORIES IN THE ARAB REGION

It would be unfair to say that no effort has been made to establish a reliable statistical basis for the development of science and technology in the Arab region. The Evaluation of Scientific and Technological capacities in Mediterranean countries (ESTIME), funded by the European Union (EU) between 2004 and 2007, was one such attempt; the 2007-2012 Mediterranean Innovation and Research coordination Action (MIRA) included the creation of an observatory as part of its objectives. In three workshops, MIRA produced a white paper outlining plans for the observatory.[20] Experience has shown that the observatory's indicators units would have to manage a variety of data: input data on resources (money, human resources, other resources), output data on results of research and innovation (publications, innovation, patents), and relational data, showing networks and collaborations or connections.[21] No entity has yet been created in the Arab region capable of managing those different kinds of data.

Some countries, like Jordan, Lebanon and Tunisia, have actively sought to create observatories. Their fates are still unclear. The Jordanian project was halted; Tunisia dismantled its observatory for political reasons during the Ben Ali era. The project has not yet been revived, although formally the observatory has been maintained as an office inside the Ministry of research. Lebanon has declared the need to create an observatory in its science and technology plan; the National Council for Scientific Research (CNRS) has launched the Lebanese Observatory on Research, Development and Innovation – and alongside it, the first feasibility study, funded by ESCWA. The Lebanese Observatory's first initiatives, including and innovation survey, science and technology survey, and the establishment of indicators, are currently underway.

For many years, Morocco has had an intense discussion on the topic of an observatory, and in the framework of a Morocco-European Union 'twinning' project, the issue has again been raised with the Ministère de l'Enseignement Supérieur, de la Recherche Scientifique et de la Formation des Cadres, the Academy of Science and the Moroccan Institute for Scientific Information. In the Arab region, ESCWA has repeatedly proposed to include an indicators observatory as a support for policy-making. The newly created ESCWA Technology Centre, based in Amman, includes an indicators unit that is awaiting activation. At some point in the last five years, many countries have mentioned a similar effort, but this was rarely translated into concrete action.

Looking at the successful experiences of countries that have developed an indicators unit for science and technology, for example in Latin America, we find that in all cases, the unit has been supported by an academic team, or at least a policy-making 'think tank' that is composed of academics with backgrounds in various social sciences, as well as natural and exact sciences. There is, moreover, a virtuous cycle established

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[17] www.globelics.org.

[18] FEMISE, UNIMED, THETYS, UNICHAIN, MEDGRID, ANIMA, among many others. The World Bank in association with the European Investment Bank have created the Centre for Mediterranean Integration (CMI) in an effort to gather forces. The CMI hosts a Knowledge Economy for Growth and Employment in MENA program. http://cmimarseille.org/. In the forthcoming book of the MIRA project these will be mentioned in some detail (to be published in 2013 as special issue of the journal *Options méditerranéennes* of CIHEAM).

[19] Mouton and Waast, 2009.

[20] www.miraproject.eu (search 'observatory' to retrieve the relevant documents).

[21] Barré, 2001.

between (a) the fulfillment of policy objectives; (b) the provision of adequate information, processed in an intelligent way and responsive to policy needs; and (c) the production of 'basic' knowledge on the science and technology community, the interaction of different scientific areas, and the productive and service sectors. The Latin American experience demonstrates the value of this close connection between academic work and the development of science and technology policy.[22] A similar development exists in Asia centred on the concept of regional innovation systems: indicators appeared as a result of the development of regional clusters of production and technology, and the governments' desire to understand and promote this economic phenomenon. Thus in Malaysia, Thailand, and China, indicators appeared from offices responsible for industrial policy-making.[23] This example illustrates that indicators can emerge as a by-product of intellectual effort to understand science and technology in the particular context of each country.

### C. Types of sources and indicators

In the absence of reliable and robust indicators, two strategies are normally employed: the first is opinion surveys or polls; the second is rankings based on composite indicators that can compensate for the diversity of sources.

Policy makers and, more importantly, investors prefer to rely on indicators drawn from opinion polls. This method, used by the renowned Global Competitiveness Report (produced for the World Economic Forum in Davos) for example,[24] relies on a survey of persons considered 'knowledgeable informants', that is, professionals with particular knowledge and insight of research and innovation activities. Professors, academics, entrepreneurs and policy-makers are asked to grade a series of variables related to different aspects of research and innovation. This mitigates the risk of false or incomplete data; nevertheless, the view of the field is reduced by the mean of opinions expressed by this collection of informed persons. Since no one can claim to have a global view of the sector, this is considered as an acceptable way to show the state-of-play. The identity of the persons responding to this kind of survey is as important as the points of view they express. Moreover, the answers obtained are measured using some ranking method which produces a 'mean' opinion not necessary reflected by any real social actor.[25] This average opinion becomes a social norm by itself; it could well be said that it reflects the demise of our capacity to modify this social norm.

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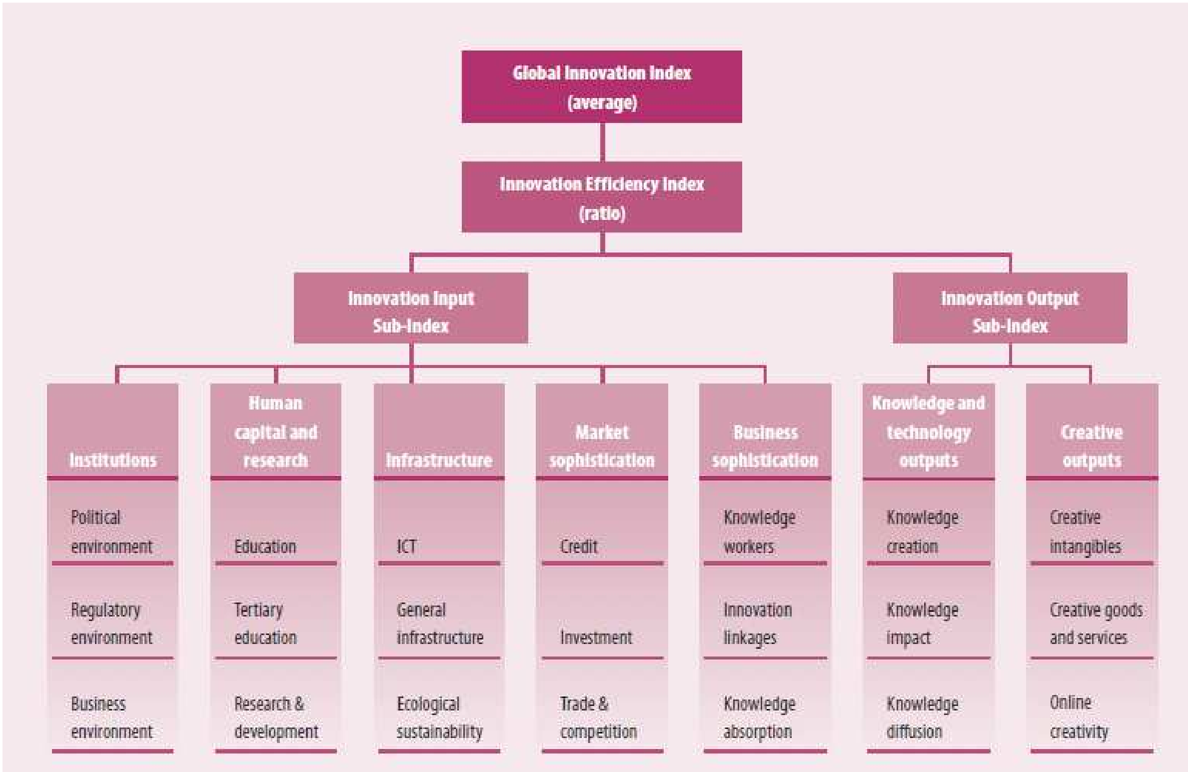
[22] Arellano et al., 2012.

[23] For South-East Asia see the special issue of *the Journal of Science, Technology and Society*, March 2006 Vol. 11, N° 1. In particular the introductory article by P. Intarakumnerd and J. Vang. On China, see '*China Innovation Inc.*' edited by R. Bironneau, 2012.

[24] Schwab, K. and X. Sala-i-Martín, eds. 2012, *The Global Competitiveness Report 2012-2013*, Geneva: World Economic Forum.

[25] Socio-economic literature is abundant on these matters. A recent case of reflection can be found in the study published by Leresche, J. et al., eds. 2009. *Recherche et enseignement supérieur face à l'internationalisation. France, Suisse et Union européenne.* Lausanne: Presses polytechniques et universitaires romandes.

**Figure 1. Global Innovation Index framework (INSEAD)**




A second strategy, employed by the World Bank and INSEAD's Global Innovation Index, relies on more general indicators and transforms the variables either into rankings or marks. This strategy also enables the creation of somewhat more robust (though less detailed) indicators. The rationale behind these kinds of complex indicators is their ability to reflect the various factors contributing to a country's competitiveness, level of innovation and so on. In its knowledge assessment methodology, the World Bank (2012) used a four-pillar set of indicators. They are: (1) economic incentives and the institutional regime, (2) innovation and technological adoption, (3) education and training, and (4) infrastructure in information and communications technologies.[26] A similar methodology has been proposed to measure the Europe 2020 strategy for smart, sustainable and inclusive growth within the European Union, which was launched by the European Commission in March 2010 and approved by the Heads of States and Governments of the 27 member states of the European Union in June 2010.[27] For Europe 2020, also known as the 'Lisbon Strategy', complexity is reduced to eight indicators. A similar methodology has been proposed by Dreher for measuring 'globalization' in three dimensions: social, political and economic.[28] The best-known index employing this kind of methodology is the World Economic Forum's Global Competitiveness Index, comprised of 12 pillars, which ranks 133 economies. Technological readiness and innovation are two of its 12 pillars. Finally, INSEAD has developed a Global Innovation Index[29] covering 141 countries. This Index relies on a series of indicators grouped into five input pillars of innovation: (1) institutions, (2) human capital

[26] Ibid.

[27] Pasimeni, 2011 and 2012.

[28] Dreher, 2006 and 2008.

[29] INSEAD, 2012.

and research, (3) infrastructure, (4) market sophistication, (5) business sophistication. Two output pillars capture actual evidence of innovation: (6) knowledge and technology outputs and (7) creative outputs (figure 1). The Global Innovation Index is quite consistent and is used for the analysis of this report.

## D. Bibliometric indicators and impact

Usually, two reliable sources of research output are used to measure science and technology innovation: publications and patents. Both of these sources, however, rely on the existence of databases which are in turn dependent upon a specific social and economic system: the publication system in science, on one hand, and the patenting system, on the other hand. In the case of scientific publications, scientific and financial considerations compete for primacy in the relationship between authors and publishers. The network of scientists that evaluate the quality of scientific articles (usually anonymously) and the control the circulation of ideas and scientific results has been referred to as an "invisible college", with journal editors acting as "gatekeepers".[30] Today, this social organization is becoming increasingly complex, with the hierarchy of journals, disciplines, institutions and countries ever more difficult to disentangle. Part of the debate on the validity of the impact factor stems from this discussion: it is because the structuring of the scientific community has become so diverse that no specific system or institution can claim primacy.

With regards to patents, national economic and research policies, as well as strategies developed by firm, organize to the patenting system. Japan and South Korea, for instance, are very high-patenting countries in part because the patenting strategy of their firms is to register multiple patents for a single product, rather than one patent covering most aspects of an invention. Complex strategies are elaborated that take into account the cost of patenting and expanding patent protection to other countries, alongside the risk of revealing information. After all, patenting is more than a legal tool; it is also a kind of publication, and as such it discloses information about the technology in question. Both forms of publication, whether in academic journals or through patents, are not 'objective' indicators: they depend upon strategies and social organization. Thus publications and patents do not simply reflect performance (or impact); they also demonstrate a society's acceptance of the outputs, and are thus part of a social system.

Nonetheless, bibliometrics (statistical indicators of publications) is still considered the most reliable source on scientific production, mainly because it is independent of national authorities. Only two large databases of citations exist, produced by two major publishing entities. Thomson produces the Web of Science, and Elsevier produces Scopus. Both databases are commercial activities as much as they are sources of information. While they are not the only two sources available,[31] they share the aim of being multidisciplinary, independent, and of providing information on author affiliations and citations.

It should be noted that new methods have been proposed for bibliometrics, focusing more on strategy than evaluation, and engaging in analytical and mapping analysis.[32] Relational analysis, based either on words or citations, are complex[33] and a whole new field is emerging that can also be mobilized for use in the Arab region. This will require the training and stable employment of information engineers to be effective. Another issue related to indicators is the measurement of impact, strictly speaking, and is not related to citations (see 'issues related to impact', page 49). As mentioned in the 2011 MIRA white paper, the impact of scientific research can be measured relatively accurately at the level of a project, but this accuracy diminishes as the level is increased; thus disciplinary studies are less accurate than project studies, and

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[30] This terminology has recently been remembered by Caroline Wagner, 2008. *The New Invisible College. Science for Development*. Washington D.C.: Brookings Institute Press.

[31] See Arvanitis and Gaillard, 1992 for a review of these issues.

[32] Lepori, Barré et al., 2008.

[33] Good examples are the tools proposed by Loet Leydesdorff or the IFRIS Cortext platform. The bibliometric work once based on exploiting on-line data, went next to desktop research and now returns to on-line collaborative research.

country studies are less accurate than disciplinary studies.[34] Thus, concludes the MIRA white paper, impact measurement should better concern a programme than a discipline or a country.

Impact of research is a complex concept that must take into account not only the disciplines being measured, but also the structuring of the scientific community by consolidating research teams, research networks, and research organizations, and its capacity to generate new and original research projects. Measuring how new teams are set-up, consolidated, and how they collaborate worldwide is the only possible impact assessment that would take into account the social dynamic engaged by the researchers and their institutions. Certainly, this kind of measurement would be more meaningful than one based on the number of citations received by a publication (wrongly called 'impact measurement'). Finally, visibility of research is a concept that should certainly be used more frequently than is the case today.

So far, the Arab region has not benefited from a similar exercise in measuring the impact of research activities. More generally, programme managers have been interested in measuring the impact of research on the ground, which translated directly into research capability; but it is difficult to extrapolate from this kind of measurement to the research capability of an entire country.[35] Most national exercises use the kinds of data presented so far. No country in the Arab region has even made use of the comparatively straightforward scoreboard based on publications, including Morocco, where the concept of 'publication scoreboard' has been actively promoted since the 2002 evaluation of its research system by Waast and Rossi (2009).

[34] Recently, French research institutions such as the *Institut de recherche agronomique* (INRA) and the *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD), have demonstrated the complexity of this exercise when applied research and technologies are involved. Long before that, the International Foundation for Science (IFS), an entity that funds scientists that create their own research laboratories upon returning to their home countries, developed a 'dashboard' of indicators that includes publication data and in-house surveying; this methodology, called MESIA, is a good example of a programme-oriented impact assessment. Technopolis, a European academic-based consulting firm specialized on science and technology policies, has also developed an impact assessment methodology based on the measurement of relevance, efficacy, efficiency, and an array of indicators that could reflect the measurement of impacts of research programmes. The European Union was particularly prolific on this topic in the 1990's (Callon et al., 1997).

[35] A recent effort was made to evaluate impact at mid-term of ERAWIDE projects. See the forthcoming and final MIRA book.

## III. CHARACTERIZING NATIONAL RESEARCH SYSTEMS IN THE ARAB REGION

This section presents an empirical descriptive analysis of research systems in Arab countries. We have long wanted to test the significance of indicators commonly used in most publications about science and technology in the Arab region. These indicators are employed to develop a typology of research systems which, hopefully, would help solve the riddle of underinvestment in scientific research in Arab countries. The virtue of the exercise is to relate equally patterns of publication, aspects relating to the organization of the research system, the role of universities, and other factors. This empirical approach focuses less on a country's ranking than on the characterization of their profiles highlighting what makes a difference between one profile and another.

### A. MOBILIZING THE DATA FOR THE FACTOR ANALYSIS

After reviewing the available data, we had to use most of the standard data meaningful at the national level. These macro-indicators, even if not very accurate, point in a certain direction, and show a tendency that we would like to collect. One hundred and fourteen (114) indicators were found in the literature, from a large variety of sources, and many of these were redundant. Table 2 gives the final list used for the factorial analysis.

TABLE 1. TOTAL EXPLAINED VARIANCE

| | Total | Variance | % Cumulated |
|---|---|---|---|
| 1 | 5 057 | 31.608 | 31.608 |
| 2 | 2 980 | 18.625 | 50.233 |
| 3 | 2 238 | 13.991 | 64.223 |
| 4 | 1 491 | 9.317 | 73.541 |
| 5 | 1 112 | 6.953 | 80.493 |

### B. FACTOR ANALYSIS

Principal component factor analysis was conducted[36] to assess the underlying structure for the statistical items gathered. Before performing the factor analysis, the data were "reduced" to percentile groups in order to eliminate the distortions that could be introduced by the mere size effect, due to the large variety of scales of each data.

Table 2 shows the different types of data:

- *Indicators of size*, such as the number of professors, students, researchers, volumes of production (in number of articles); shares of global scientific production; and gross expenditures in R&D (GERD);

- *Proportional indicators* that relate science production and the number of researchers to the size of the population;

- *Indicators of changes*, such as the growth rates of scientific production;

- *Complex indicators* based on the General Innovation Index (INSEAD), or the assessment of R&D business investment (Competitiveness Report of the World Economic Forum), as indicated in section 2 above. Their ranking is often used to complement the lack of data that exists on these activities.

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[36] No Varimax rotation was performed.

## GENERAL LIST OF VARIABLES

GDP (in billion US$) (2010)

GDP per capita US$ (2010)

GDP per capita US$ PPP

Rank HDI (2007)

Total population 2010

Growth (per cent) (2010)

PPP gross national income/Per capita US$ (2010)

Manufacturing, value added (per cent of GDP) (2010)

Value chain presence (2007)

Personal computers per 1000 people (2009)

Internet users per 1000 population (2009)

Knowledge Economy Index 2012 (out of 145)

EFA Development Index (EDI) (2008 Ranking) out of 127

Literacy level

Per cent Literate adults

Per cent Literate young (15-24)

Per cent Students/pop that can attend

Total enrolment (2004)

Secondary enrolment (per cent)

Tertiary enrolment (per cent)

Public expenditure per student as a per cent of GDP per capita (2004)

Public expenditure on education as per cent of GDP

Public expenditure on education as per cent of total government expenditure

Teaching staff

Total number of graduates

Gross Domestic Expenditure on R&D – GERD (as a per cent of GDP)

Private sector spending on R&D (Rank)

GERD financed by abroad

Per cent GERD financed by abroad

Business Enterprise Expenditure on R&D (BERD)

BERD financed by foreign owned companies and per cent

R&D budget/GDP per cent

Technology Balance of Payments

Specialized government research center

Centers at universities

Laboratories

Branch research units

Technological Research cities

Global Innovation Index (GII) Ranking 2012 (out of 141 countries)

PCT patents application per million population

Patents (USPTO patents granted to residents of Arab countries 2008/Number of patents in 2005-2006

Average annual number of patents (2002-2006)

Trademarks

Academic Ranking of World Universities (ARWU) 2010

Expenditure on higher education (in million) (budget of the ministry of higher education)

Expenditure on higher education (per cent of GDP)

Expenditure on higher education per student

Number of universities

Number of students

Number undergraduates

MSc Students (2006)

Ph D students (2006)

Number of faculty

Number of researchers (2005)

Local Collaboration

Regional collab. (with the Arab region)

Internat. Collaboration (2005)

Researchers per 1 million inhabitants

Estimates on full-time equivalents (FTE) (2008)

Estimates on full-time equivalents (FTE) per million population

Number of Scientists and Engineers in referee journals (2010)

Number of Scientists and engineers established in the United States

Number of publications

– in Basic Sciences 2005

– in Natural Sciences 2005

– in Food Sciences 2005

– in Applied Sciences 2005

Share of Arab publications (2005)

Scientific publications per 1000 publications

Number of articles per million inhabitants (2005)

Scientific articles per million inhabitants (2008)

Co-publications (2008)

Regional co-publications (2005)

Publications in Wos/Scopus

Language of publication

Specialization index

Per cent World shares (2004)

Growth of publications (2001-2006) in world shares

Government bodies responsible for R&D policies and co-ordination in the Arab region, 2006

Existence organization of Min. research, or Ministry of S&T

Co-ordinations/Funding Agencies, Other funding mechanisms

Document that defines the national research strategy

Type of Governance in S&T

Expenses on Scientific Research (2005)

S&T Policy document

Brain drain and rank out of 142 countries

Company spending on R&D

Quality of scientific research institutions

University-industry research collaboration

Local availability of specialized research and training services

Firm-level technology absorption

Value chain presence

FDI and technology transfer

Capacity for innovation

Quality of management schools

Availability of scientists and engineers

Laws relating to ICT

Intellectual property protection

Efficiency of legal system in settling disputes

Quality of math and science education

Internet access in school

FDI (in millions USD)

## C. Understanding the diversity of variables

The first five extracted factors represented 80 per cent of the total variance[37] (table 2) which can be considered a very satisfactory result. Each factor is a component of the analysis that needs to be explained by the variables that are best 'loaded' in this factor. The variables' representation (or 'loading') in each component allow to interpret the factors which are otherwise mere statistical constructions. Table 2 displays the variables and components loadings for each extracted factor.

Moreover, each factor can be shown graphically. It is usual to limit the graphic representations to the two main factors, factor one being represented as the horizontal axis and factor two as the vertical axis.

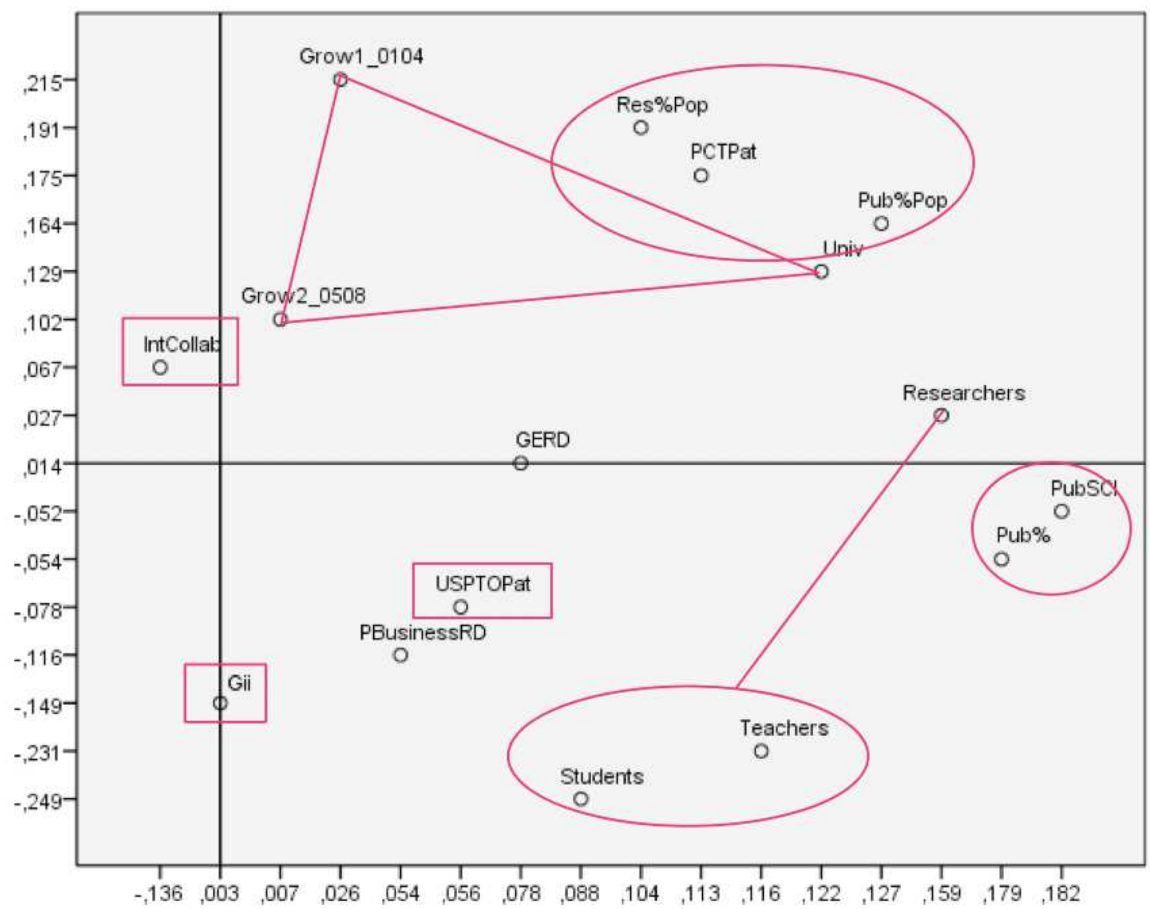
[37] The variance expresses the dispersion of the data.

TABLE 2. VARIABLES AND COMPONENTS[a/]

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Students 2007 | 0,446 | -0,743 | 0,315 | -0,221 | 0,085 |
| Teaching staff 2004 | 0,587 | -0,687 | 0,207 | -0,079 | -0,116 |
| GiiRanking 2012 out of 141countries | 0,014 | -0,445 | 0,32 | 0,698 | 0,278 |
| Business R&D expenses (ranking 2008) | 0,275 | -0,344 | 0,046 | -0,225 | 0,768 |
| USPTO patents granted to residents of Arab countries 2008 | 0,282 | -0,232 | -0,824 | 0,085 | 0,008 |
| World Share (Publications SCI) | 0,905 | -0,162 | -0,13 | 0,104 | -0,177 |
| Publications SCI [38] 2008 | 0,918 | -0,154 | -0,217 | 0,013 | -0,019 |
| GERD 2007 | 0,393 | 0,041 | 0,381 | 0,297 | -0,302 |
| Researchers 2005 | 0,805 | 0,079 | 0,201 | 0,405 | -0,097 |
| Internat. Collab (co-authrohip) in SCI | -0,689 | 0,2 | -0,062 | 0,463 | -0,001 |
| Growth 2005-2008 | 0,037 | 0,303 | 0,706 | -0,505 | -0,18 |
| Number of Universities 2006 | 0,616 | 0,385 | 0,415 | 0,083 | -0,071 |
| Scientific Articles per 1 million population 2008 | 0,644 | 0,488 | -0,207 | -0,287 | 0,169 |
| PCT patents applications per million population | 0,572 | 0,522 | -0,393 | -0,064 | -0,035 |
| Researchers per 1 million inhabitants 2007 (UNESCO) | 0,528 | 0,57 | -0,119 | 0,216 | 0,172 |
| Growth 2001-2004 | 0,131 | 0,641 | 0,421 | 0,136 | 0,441 |

a/ Principal component analysis with no rotation of axis.

**Figure 2. Diagram of variables**




[38]Science Citation Index (SCI)

Figure 2 displays the projection of variables on the plane formed by two main axis (or main components). The first axis in figure 2 represents the first component (31.6 per cent of the total variance), and is relatively easy to interpret in both statistical and substantive terms. It identifies, on the left side, the paramount importance given to international collaborations, as measured by co-authorships; and on the right side, indicators of scale (i.e. mass indicators, such as the size of student and teacher populations, shares of world scientific production, etc). This means that international collaboration is the variable that permits to differentiate most clearly the profiles of the countries; the degree of connection with foreign scientists is thus of great significance. In bibliometric analysis of large and medium-sized countries, international co-authorship accounts for around 50 per cent of scholarly production; in smaller countries, the rates tend to be higher. Larger and more diversified countries have levels of international collaboration lower than 50 per cent. There is thus a direct relation between the size of a country's scientific community and the level of international collaboration. Therefore, the axis indicates that, while the size of a country permits the ranking of its research system, it is in fact the correspondence between size and level of international collaboration that makes the difference.

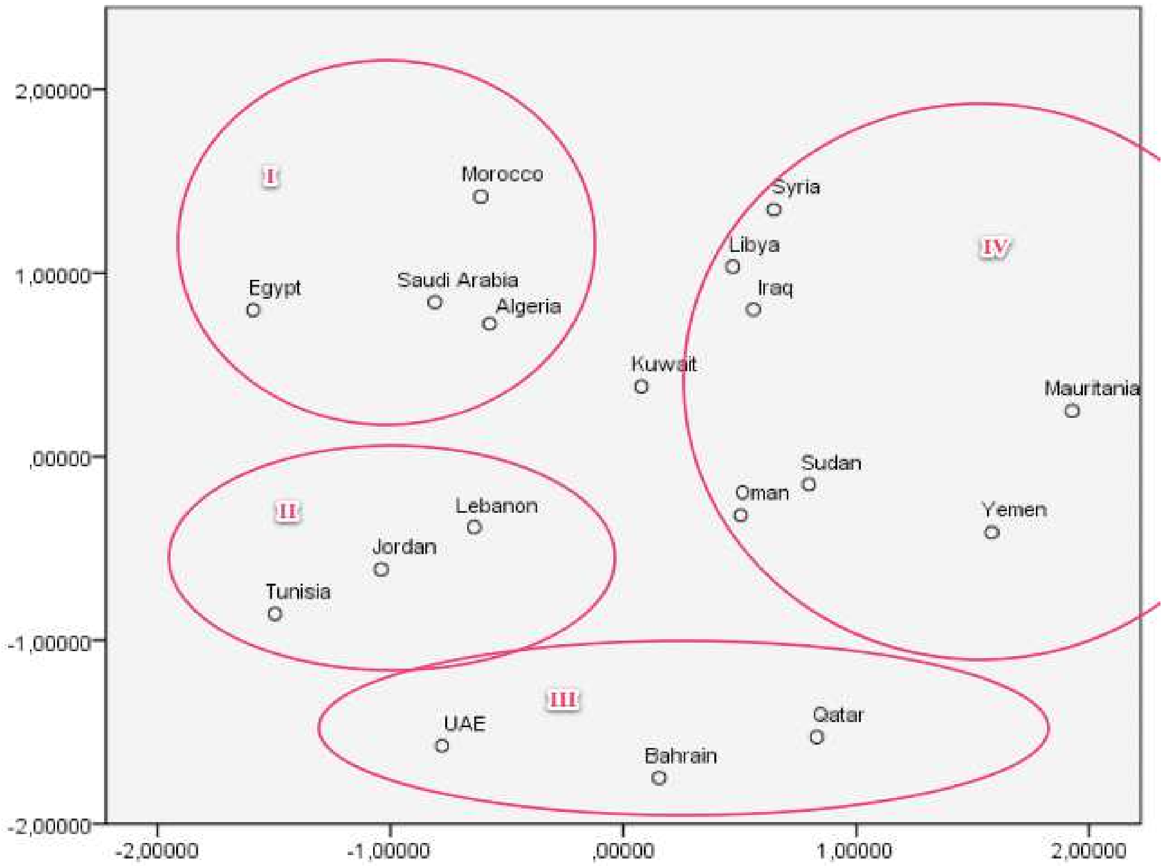
The second component is represented by the vertical axis. As can be seen from table 2, the ranking of variables is extremely different. On one side (upper part of the axis) we see the importance of growth rates of production and of proportional indicators (researchers per million inhabitants and articles per million inhabitants); on the other side (lower part) we find indicators of the university system (number of students and professors), the relatively complex General Innovation Index (GII) indicator, and an indicator of the involvement of the private sector (research and development business expenses as evaluated by the Competitiveness Report);[39] with less important contribution to this component, we find patents from the United States Patent and Trademark Office, or USPTO). Interestingly, applications for patents from the Patent Cooperation Treaty, or PCT (which are easier to obtain than from the USPTO) are represented on the opposite side of this second axis, which can be easily explained by the fact that PCT patents are more closely related to indicators of size than USPTO patents, which result from a deliberate strategy of firms looking for protection of their innovation in the United States. Also, many applicants first begin filing a PCT patent and, if the product and the market are worth it, subsequently file a USPTO or European PTO patent. The opposition in the axis is thus a good indicator of degree of importance of innovation into the research system. Most of the weight in the second axis falls upon the size of the university system, larger countries being on the upper part of axis 2 and smaller university systems on the lower part. In brief, the axis represents a closer relation to innovation and productive outputs as opposed to variables expressing size and growth.

The third component, not represented in the figure (table 2), locates on one side indicators of output (patents and scientific publications), and on the other side growth rates of publications (which are dynamic indicators of active involvement in research), indicators of size of the university system, and the GII indicator. This component thus distinguishes between systems that are heavy producers and those with lighter rates of production, but which are nonetheless very dynamic. For Arab countries, which make a relatively small contribution to global scientific innovation, this has very unique meaning: their dynamism serves to balance this low rate of production. Any explanation concerning the research system should therefore be able to satisfactorily explain both the low rate of production and the dynamism (here, the Gulf countries play a significant role).

The fourth component compares the growth rate of publications between 2005 and 2008 to the rate between 2001 and 2004, contrasting them against the more complex and fundamental indicators of the research system (GII, international co-authorship, researchers per inhabitants). This component serves to distinguish between newer research systems in Jordan and the Gulf and the more established ones in the Maghreb and Lebanon.

[39] Schwab, K. and X. Sala-i-Martín, eds. 2012.

**Figure 3. Countries represented in the space of two main factors**




Finally, a fifth component opposes resources and results; on one side we find GERD and human resources, and on the other side, older growth of publications (2001-2004), GII ranking, and scientific articles per million inhabitants. Interestingly, it also shows private sector involvement in research and development as a result. The validity of this assumption has been confirmed through empirical research in the universities of several Arab countries, and its significance should be emphasized: involvement in research and development does not depend upon the size of the university system.

Many messages are delivered to us by this first analysis. First, size indicators, dynamic indicators, and innovation indicators allow for a typology of Arab countries. Thus, next alongside size, the importance of co-authorship is made apparent: international collaboration plays a very important role in the more rapidly growing countries but also in more consolidated research systems. Those countries with high levels of co-authorship (Jordan, Lebanon, Morocco and Tunisia) are countries with rapidly expanding scientific activity, a longer history of academic research than other Arab countries, and a trend towards consolidation of their research system. These countries also share a specialization pattern different from the other countries; they are more focused on biology and medicine, whereas the dominant discipline is engineering in most other Arab countries. In recent years Egypt has enjoyed a renewal after many years of relatively sluggish scientific production and an exaggerate production in the engineering field. The rate of its international collaborations has also increased, along with new growth in areas that had been largely abandoned, such as health and biological sciences, which are now gaining on chemistry and engineering. Only Algeria remains focused on engineering and material sciences, making its production profile similar to that, for example, of China.

## D. Grouping countries by their statistical characteristics: A first typology

Figure 3 represents countries on this same space formed by the first two axis, where variables related to size (and thus, larger countries)are on the left; smaller countries are on the right; dynamic variables are pulling on the lower part of axis one; and the size of the university system is on the upper part of this space.

In effect, we see larger and more dynamic countries on the upper left part of the graph; small and dynamic countries on the lower left part; and less dynamic countries on the right part of the diagram (the scale is not exactly the same for variables and for countries: countries vary on a wider scale than variables). Kuwait has always occupied a relatively central position on this graph, with most of its variables tending towards the middle of the spectrum.

Based on this measuring of the variables, four distinct groups of countries emerge:

*Group I*: Large research systems with slower growth, relative to other Arab countries: Algeria, Egypt, Morocco and Saudi Arabia. These are comparatively large or rich countries. Egypt is unique in this group (or any other), set apart by its lack of natural resources. But the group is basically aggregating larger research systems characterized by a certain amount of inertia, slow growth and consolidation of international collaborations. Morocco has only recently entered a period of sluggish growth following the rapid expansion of its research system in the late 1990's, a phenomenon explained by the return of many Moroccan academics that had been living abroad. It is the most diversified system in the sample. Kuwait, which stands in between Groups I and II, could for analytical purposes be integrated into Group I, given its older, more established strategy of research support. Only its small size distinguishes it from the other countries in this group. Egypt and Algeria share a very similar profile of disciplinary specialization, which will be explored in more detail below.

*Group II*: Small, dynamic and integrated research systems: Jordan, Lebanon and Tunisia. These are the countries with the highest rates of publications and growth of production. They are also small countries with proportionally high numbers of researchers and of scientific production. Although their scores in overall innovation are low, these countries tend to have niches of innovative activities. Intriguingly, Tunisia has a very centralized research system, while Jordan and Lebanon do not. Had there been an indicator to measure level of centralization, the categorization of countries would likely have been different; however, recent work has confirmed that Jordan, Lebanon and Tunisia are engaged in an active pursuit of scientific research and consolidate the evaluation systems inside their universities. Jordan is the country that has changed most recently, with a surge in its scientific production.

*Group III*: Very small countries with rapidly expanding research systems: Bahrain, Qatar and the United Arab Emirates. These are very small, rich Gulf countries, with an active policy of developing technologies and universities, actively pursuing branding strategies for their universities and seeking to capitalize on their high-level resources.

*Group IV*: All other Arab countries. It is quite difficult to differentiate between these small and less integrated research systems. Some universities seem to be developed, but scores are low for many variables. Iraq has been placed in this group, as it has yet to engage in the reconstruction of its once well-regarded university system.

TABLE 3. FOUR INTUITIVE INSTITUTIONAL MODELS IN ARAB COUNTRIES

| Type | Countries | Main features |
|---|---|---|
| The Gulf model | Gulf countries | Decentralized trade-oriented governance<br>Public universities open to foreign teachers/researchers<br>Research based on international collaborations<br>Foundations for research |
| The Middle East model | Syria<br>Egypt<br>Iraq | Centralized type of governance<br>Research in large public research centers and universities<br>Large public universities |
| The Machreq model | Lebanon<br>Jordan | Decentralized governance<br>Research concentrated in universities (in Lebanon mainly private universities) |
| The Maghreb model | Algeria<br>Morocco<br>Tunisia | Centralized governance<br>Large public universities<br>Research mainly in universities and public research institutes |

*Source*: ESTIME, 2007- own presentation.

## IV. THE GOVERNANCE OF RESEARCH SYSTEMS

As part of the ESTIME project, four models of governance for the Arab region were identified based on the degree of centralization of the system as well as the relation to the economy and society (table 1). Taking this first, intuitive categorization into account, the following discussion on the governance of research systems will consider history, centralization, dynamism and performance before proposing a renewed typology.

*History*

The models proposed in table 6 are based on historical precedent and not performance. It makes sense to take history into account because it shapes institutions and the research path taken by a country (see Introduction).

Arab research centres at first focused on basic sciences and medicine. They subsequently diversified their programmes to include general applied specializations. Over the past two decades, human, social, and environmental sciences have also been added. More focused centres have been created, usually because of the availability of specific, usually international, funding; for instance, there is a focus on locally significant palm tree research in a number of Gulf countries. Traditionally, agricultural research depended on ministries of agriculture, which have been quite important in Egypt, Morocco, the Syrian Arab Republic and the Sudan. International agricultural centres, like the International Center for Agricultural Research in the Dry Areas (ICARDA), headquartered in Aleppo,[40] have also played an important role in structuring the research in this field; desertification, water pollution and management of water resources have been promoted through French bilateral cooperation, mainly with Tunisia and Morocco; linguistic research in the Maghreb grew out of interest in Amazigh language and historical research; the Balka research centre in Jordan grew out of international (mainly British) funding on environmental sciences. Many research projects are currently being implemented through partnerships with Western industrial States and the exchange of scientific visits and training.

Egypt currently has the largest number of research centres (14specialised government research centres, 219 research centres under the auspices of ministries, and 114 centres at universities). In Tunisia there are 33 research centres comprising 139 laboratories and 643 branch research units.[41] Technological research cities are few, limited to Egypt, Saudi Arabia, and Tunisia and they have very different forms and functions. The ANIMA Investment Network is the main networking tool among them. Some new research cities are under way in the Gulf countries (box 2): they usually link research to an institution of higher education (such as engineering school or university) and a hospital or business. There is a general trend towards the promotion of technoparks and science cities. Apart from those mentioned in box 2, there is the Science and Technology Oasis under the umbrella of the Qatar Foundation (UNDP, 2009:188). Tunisia has had the most ambitious technoparks system which, although not growing as quickly as intended, has nevertheless been effective in some cases (see National Innovation Systems).

*Centralisation*

The relation of research to the State is very central: larger countries usually have a more “centralized” science policy system. Centralization can also, however, operate in smaller countries like Tunisia. Moreover, centralization has no relation to performance. A totally decentralized system like Lebanon, an exception in the Arab region, performs as well as Tunisia, which is small and centralized. The concept of a

[40] The Consultative Group on International Agricultural Research is based in Washington and groups fifteen international research centers. www.cgiar.org/. ICARDA is the only center based in the Arab region.

[41] Figures have changed since this assessment, but more or less the number are close, for a complete overview see ESTIME background report on Tunisia: M’henni, ed. 2007, ‘*Le système de recherche en Tunisie*’, Tunis: Bureau des Etudes Prospectives, de la Planification et des Statistiques. Background report for ESTIME. http://www.estime.ird.fr/article240.html.

National Council (rather than a Ministry) as a central coordinating figure for science policy is an indicator of this absence of centralization. The "English" system of councils fits well with decentralized countries. The "French" system of a central state administration for both higher education and research is more easily applied in larger countries. However, caution must be taken with this gross generalization. Egypt is in a process of rapid "decentralization" of its science policy, following an original course that has no historical precedent in the country. It has dismantled its Science Academy (modelled on the Soviet Academy of Science) and is now transitioning to a quasi-council and programme-based funding. The same goes for Morocco which, within a centralized administration, is undergoing a series of state initiatives from competing government Ministries and the King's Makhzen.

In most Arab countries, research is the responsibility of ministries of higher education and scientific research (eight countries), ministries of education (three countries), and a ministry of planning (one country), in addition to some specialized ministries (agriculture, health, industry). Five Arab countries (Bahrain, Kuwait, Lebanon, Qatar, and the United Arab Emirates) show an exception to this trend, having assigned the task of research and development to relatively independent councils and academies.[42] In Lebanon, for example, the National Centre for Scientific Research (CNRS) has functioned primarily as an agency distributing research grants on the basis of competitive calls for proposals. The CNRS also has four institutes of its own, but these are relatively small.

TABLE 4. GENERAL DESCRIPTIONS OF RESEARCH SYSTEMS IN VARIOUS ARAB COUNTRIES

| Country | S&T Policy document | Permanent policy making bodies with national authority | | Funding Agencies | Other Funding Mechanisms | Type of governance | GERD/GDP (*Percentage*) |
|---|---|---|---|---|---|---|---|
| | | Council | Ministry | | | | |
| Algeria | Yes<br>(Nat.Plan, 1998) | | Yes | | Nat Res progs + National Fund RTD + | Centralized | 0,25* |
| Morocco | Yes<br>(Vision 2006) | | Dept of a larger minister<br>(since 2004) | CNRST | Various Funds to support innovation: PTI, Incubators | Centralized | 0,8* |
| Tunisia | Yes<br>($5^{th}$ Plan and following Plans since 1977) | | Yes | Nat Sc Res Foundation (since 1989)<br>Et al. | Various Funds to support innovation: FRP, NPRI, PTI, Techparks | Centralized | 1,2** |
| Egypt | No | Formerly:<br>Ac. Of Sc. | Yes | STDF and other funds | Initiatives from various Ministries: Agri, Indus, Telecom, etc. | Centralized | 0,2** |
| Lebanon | Yes STIP (2006) | Yes CNRS | - | CNRS<br>Since 1962 | Performers get contracts from all sorts of sponsors | De-centralized | 0,3** |
| Jordan | No | Yes HCST | - | HCST since 1987 | Performers get contracts from all sorts of sponsors | De-centralized | 0,34* |

[42] Nabil 'Abd al-Majid Salih, 2008, in Arabic; UNDP, 2009, p. 188.

TABLE 4 (*continued*)

| Country | S&T Policy document | Permanent policy making bodies with national authority: Council | Ministry | Funding Agencies | Other Funding Mechanisms | Type of governance | GERD/GDP (*Percentage*) |
|---|---|---|---|---|---|---|---|
| Syria | No | Newly established (2007) | - | No | | De-centralized | 0,12** |
| Bahrain | _ | ? | - | BCSR (acting as agency) | | Trade oriented | 0,04 ** |
| Oman | _ | ? | - | OCIPED Invest Promo 2002 | Sponsors | Trade oriented | 0,07** |
| Emirates | _ | Institutional research and strategic planning | - | | Sponsors | Trade oriented | 0,2 |
| Qatar | _ | | - | Qatar Foundation | Sponsors | Trade oriented | 0,6** |
| Kuwait | _ | Still in discussion | Yes Min High Edu and Sctf Res | KFASFunding and coord since 1988 | Sponsors | Semi-centralized | 0,2 |
| Saudi Arabia | | KACST | Ministry ? | KACST since 1977 | | Centralized | 0,14** |

*Source*: ESTIME project Final report (2007). Kuwait and Saudi Arabia: Recent Monographs. Data on GERD as % GDP come from UNESCO (2010) when * and UNDP (2009) when **.

In most Arab countries, scientific research agencies are attached to, by and large, higher education systems rather than to production and service sectors. It has been stated, notably in the Arab Knowledge Report, that this contributes to the creation of a wide gap between education and research on the one hand, and research and economic and social needs on the other.[43] They advocate for a closer relationship between research organizations and industry, agriculture and other productive functions. Since most research is public, this would entail the organic connection of research organizations to a different ministry. Here, a certain degree of scepticism is appropriate: changing the attributions of research from higher education to industry would not really modify the state of play. In practically all Arab countries, there has been rampant competition between 'modernists', usually to be found in 'technical Ministries' (industry, telecommunications), higher education, and political personnel more preoccupied with national representation and the central power play. Education is usually one of the key arenas where this competition plays out. Higher education has been profoundly affected by global changes and the pressure placed on universities, to a point that goes well beyond the usual willingness of the state apparatus to control student life and rein in potentially rebellious universities. Research can find its way with difficulty under this very strenuous political pressure. This also explains the predominance of ministries of industry, agriculture, and telecommunications in innovation policies. Hospitals are also becoming a central site for research, as they are both a place of useful research and a key employer. A multiplicity of research centres and actors is thus growing. This is true in all Arab countries; thus innovation policies insist on coordination rather than production and funding, the more well-known functions of a central governmental structure in charge of research policy. Coordination, rather than production is a new and important orientation, rather more difficult to implement than the usual "capacity building".[44] It supposes, in a given country, the government will agree to take into account a rather wider span of actors than it used to do, participate in defining the

[43] Arab Knowledge Report.

[44] Arvanitis, 2003.

agenda outside the sole objectives and priorities of its own agencies, accept to be challenged on its own ground and on its sovereign decisions by agencies that are richer, stronger and with different objectives than its own. Innovation policy is probably one among many other areas were these governance issues will be abundant.

*Dynamism*

The four institutional models do not take into account the dynamism of the science sector, a key variable, as was stressed in section3. In fact, this dynamism characterizes countries where science and technology are not only declared as useful, but where important investments are made. As will be shown below, money by itself does not guarantee performance, although it represents the concrete translation of pro-research policy engagement. The factorial analysis, in particular, shows that differences in growth rates as well as performance on the Global Innovation Index do make an important difference. Explaining this dynamism should be the focus of science and technology studies in the region.

*Performance*

Performance seems unrelated to structural aspects such as policy centralization, history or institutional organization. Tunisia, leading Arab countries in research, has a centralized science policy, as do Algeria and Egypt, although their performance is much lower (figure 3 presents a simplified illustration of the institutional arrangement of science and technology in Tunisia). Tunisia's research system is dynamic but fragile, because it is vulnerable to changes in policy and officials in the administration. Tunisia, more than any other country, demonstrates the extreme difficulty of promoting technological research and innovation from within the research system.[45]

A 2009 report from the United Nations Development Programme stated that funding projects through foreign capital resulted in the projects having a persistently weak impact.[46] However, no one has developed the tools needed to accurately measure the impact of these projects. In some cases, the available local funding is insufficient: one very intriguing case is that of the centres in Tunisia devoted to technological research for the productive sector. As these centres continue to grow, they are seeking additional funding. Despite their value to national development, this funding is being provided through foreign (primarily European) institutions. Another example comes from Morocco, where a very large enterprise capable of funding its own research and development has nevertheless turned towards foreign sources of funding, again primarily European. This situation is common, and the European Union has shouldered much of the cost of research and innovation projects in the Arab region. The MIRA project, a platform for dialogue between Europe and Mediterranean partner countries of the EU, has formalized this process through its promotion of a Euro-Mediterranean Innovation Space. Whatever the case, it is important to reiterate that monitoring technology and innovation policy in the Arab region is still not done systematically; thus evaluations of level of project impact make little sense at this stage.[47]

## MODELS OF RESEARCH GOVERNANCE AND POLICY

Synthesizing this discussion based on the factor analysis and the more intuitive institutional models presented above, four models for the governance of research systems can be proposed:

1. Large, centralized and dynamic research systems.
2. Large, centralized and low-performing systems.
3. Small, dynamic systems.
4. Small, flexible and market-oriented systems.

[45] M'henni and Arvanitis, 2012.

[46] UNDP, 2009, pp. 187-188.

[47] Arvanitis and M'henni, 2010.

1. *Large, centralized and dynamic research systems*

Size matters in research. Many have sought to identify the "critical mass" at which size begins to result in the under-development of research capacity. After 30years of searching for this elusive critical mass, it is time to acknowledge the fact that size also translates into a certain diversification of interests and stronger expansion of the research system. If this dynamic process is underway, not simply because the population is large, but because the growth of scientific activity is strong and consistent, then a dynamic research system can be said to exist. This is the case in Morocco and Saudi Arabia and, more recently, Egypt, which is undergoing a major overhaul of its research system. In Algeria, where the Government has recently decided to invest heavily in research, this dynamic process is also getting underway. While all of these systems are centralized, they appear able to manage the emergence of competitive funds and favour collaborations with foreign partners. With the (very notable) exception of Egypt, they are rich countries. As was the case in the factor analysis, Morocco is the most diversified system in the sample. The remaining three countries (Algeria, Egypt and Saudi Arabia) share a very similar profile of disciplinary specializations.

2. *Large, centralized and low-performing systems*

Low levels of research activity, relatively few research centres operating with limited government funding, and a lack of diversity in their financial and human resources are the hallmarks of this group, which includes Libya, the Sudan and the Syrian Arab Republic, as well as Iraq, although the latter's efforts to rebuild its formerly renowned education system are worthy of note. In these countries, public research centres are burdened with the scientific services required by public utilities, while professors are overtaxed with teaching responsibilities. Universities generally have poor records of research. As such, the contribution of these countries to the production of original research and patents are limited and do not include all scientific specializations. These countries belong to Group IV of the factor analysis. Many international recommendations appear geared towards improving the record of these countries.

TABLE 5. SCIENTIFIC RESEARCH SOURCES OF FINANCING IN ARAB COUNTRIES

| Sources | Expenses in million dollars | Expenses in per cent |
|---|---|---|
| State budgets | 840.9 | 61.5 per cent |
| University budgets | 217.3 | 27.8 per cent |
| Private sector | 12.6 | 2.9 per cent |
| External funding | 61.5 | 7.8 per cent |
| TOTAL | 782.3 | 100 per cent |

*Source*: UNESCO, 2009, p. 541.

3. *Small, dynamic systems*

The research centres in this group, which includes Tunisia, Lebanon, Jordan and Kuwait, are characterized by flexibility in their relationship with the public sector and diversity in their sources of funding and human resources. Their most significant research production remains linked to the institutions that are able to draw international support and build partnerships with industry. The institutions within this model show promising dynamism. Universities play an important role and, more importantly, there are many universities with explicit research policies. However, these countries are also characterized by the often brief tenure of their experts and their intensive domestic and international travel. Most of the countries in this model fell within Group II of the factor analysis. They boast the highest numbers of publications and growth of production. They are also small by any standard but have proportionally high figures of researchers, citation impact, and proportionally strong scientific production.

4. *Small, flexible and market-oriented systems*

Group 4 is quite similar to Group 3, but distinguished by research centres with flexibility towards, and sometimes independence from, the public sector. They are also characterized by being rich and thus able to have a diversity of funding sources, and the ability to attract specialists from abroad. A significant percentage of their scientific production comes from universities and private centres and they are able to benefit from international cooperation programs as well as from independent local funds, in the cases of Qatar and the United Arab Emirates. The countries of this model correlate to Group III in our factor analysis. They are characterized as very small, rich and rapidly expanding. Table 5 shows the rather small effort of the private sector (2.9 per cent) in financing research. These countries have been emblematic of the 'knowledge economy' because they have quite strictly applied recommendations concerning the privatization of research funding through the establishment of universities and the adoption of international standards. According to a study on science cities, these countries tend to be very responsive to policy at the international level and to a large extent have followed the recommendations of global financial institutions (Khodr, 2011). This conformity to a perfect model also indicates the difficulty of creating a research community from scratch, an experience that Singapore has also undergone (Goudineau, 1990). The complexity of turning a policy recommendation into a full-fledged research system should not be underestimated.

This categorization is not perfect. Its purpose is to stimulate a discussion on different policymaking options, according to the different circumstances faced by Arab countries.

**Box 1. Governance of science cities in the Gulf countries**

Hiba Khodr, a researcher at the American University of Beirut, studied the governance of three specialized "science cities": the Dubai Healthcare City, the Abu Dhabi Masdar City, and the Qatar Education City. These institutions are exemplary of the governance style of these entirely new entities that combine a hospital, schools, universities and scientific research.

"The decision-making process was repeatedly described in all the interviews as a predominantly centralized top-down process. The presence of a vision by the country's leadership is another common denominator to the interviewees' answers to the question related to main actors involved in policy development and formulation. […] These decision makers share the following common characteristics: they are in the ruler's circle of trust, they have access, they have vested interests, they have 'connection with the vastness of the space, otherwise they won't see the need', they have exposure to the outside world, they are competent people, they are not necessarily consultants, the majority are expatriates, and they are subject matter experts who are well known in their field" (p. 7).

Besides being established as free zones, all the cities in the study are either subsidized by the government, semi-governmental organizations, or government-funded projects. They are also located in resource-rich countries. They aim to diversify the economy and, in their design and policy objectives, they also target sustainability.

Khodr writes: "the innovation perspective is crucial to understand the implementation process of specialized cities. A specialized city seeks to be attractive not just for the home country and the region, but also for the whole world. Being the first city to implement the education, health and environment concepts on such a large scale is important and is what is common to these cities; the specialized cities-within-the-city want to become a hub and a global benchmark. They intend to gain the so-called 'first mover advantage' […] where customers tend to have a preference for the pioneers while others copy their innovative concept and buy their acquired expertise. […] The cities attract internationally well-founded institutions and foreign professors to staff massively the newly founded universities". The author continues: "Other than the profit generated from the millions of dollars endowment to the home university, the recruited foreign staff receives an attractive compensation package". Moreover, the universities are considered to add value to the city. Another common characteristic of these cities is the joining of education and research under one roof, with the ambitious aim of bridging policy and research. Finally, the pressure to conform to internationally and regionally accepted standards represents yet another policy determinant to the establishment of the three cities. Related to this, are elements of national pride and regional prestige.

Khodr, H., 2011. *The dynamics of policy innovation and diffusion in the Gulf Cooperation Council: A case study of three specialized cities*. Working Paper, Institute Issam Fares, AUB, Beirut. Available from: http://www.aub.edu.lb/ifi/.

## V. INVESTMENT IN RESEARCH AND DEVELOPMENT

The above demonstrated that gross expenditure on research and development (GERD) occupies a middle position as a differentiating indicator: it is not closely related to any particular country profile. Of course, larger countries will tend to spend more. Overall, however, funding appears to play an indirect role in defining the profile of a research system.

TABLE 6. DISTRIBUTION OF COUNTRIES ACCORDING TO GDP PER HEAD AND GERD
(*Percentage GDP*)

| Country | GDP 2010 | GDP per capita (2010) | Public expenditure on education as % of GDP (2008) | Public expenditure on education as % of total government expenditure (2008) | GERD (as a % of GDP) (2007)[a/] |
|---|---|---|---|---|---|
| Tunisia | 33.4 | 3165 | 6.4 | 16.5 | 1.20 |
| Morocco | 59.9 | 1844 | 5.7 | 25.7 | 0.75 |
| Libya* | 49.4 | 7 885 | 2.7 | 19.8 | 0.70* |
| Qatar | 54.2 | 33 932 | 2.4 | 8.24 | 0.33 |
| Sudan | 22.8 | 524 | 0.4 | 4.1 | 0.30 |
| Jordan | 15.3 | 2 534 | 4.9 | 20.6 | 0.30 |
| Egypt* | 160.3 | 1 976 | 3.8 | 11.9 | 0.23* |
| UAE | 158.4 | 21 087 | 0.9 | 27.2 | 0.20 |
| Lebanon** | 28.5 | 6 747 | 2 | 8.1 | 0.20 |
| Oman | 303.5 | 11 192 | 4.3 | 22.6 | 0.17 |
| Algeria | 79.2 | 2 232 | 4.3 | 20.3 | 0.16 |
| Syria | 31.2 | 1 526 | 4.9 | 16.7 | 0.12 |
| Kuwait | 61.4 | 25 100 | 6.6 | 14.8 | 0.09 |
| Saudi Arabia | 258.7 | 9 425 | 5.7 | 19.3 | 0.05 |
| Bahrain | 13.2 | 12 505 | 2.9 | 11.7 | 0.04 |
| Iraq | 23.6 | 736 | 5.1 | 6.4 | |
| Mauritania | 4.2 | 1 290 | 4.4 | 15.6 | |
| Yemen | 14.7 | 610 | 5.2 | 16 | |

*Source*: Arab Knowledge Report, table 5-4, p. 193.

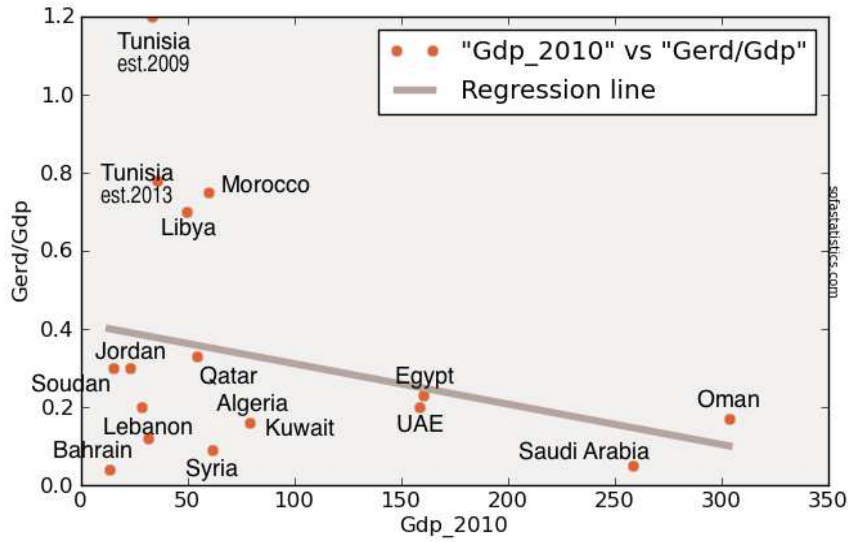
*Notes*: a/ (World Bank, 2012)

* GERD as a percentage of GDP: COMSTECH data.

** GERD as a percentage of GDP: National Council for Scientific Research (CNRS).

Perhaps a cautionary note is in order on the financial input data used in this report. Most rely on estimates, and the field experience of the authors suggests that the data are currently not being crosschecked. Rather, they are declarations made by national authorities, coming from very diverse sources. Most strikingly, national statistical institutions are not the ones providing data on research and innovation. Nor are the ministries that may be in charge of industry, agriculture or other services. In the specific case of telecommunications and information technologies, relevant government ministries have led specific initiatives; this is the case in practically all the Maghreb countries, as well as Egypt and Lebanon. In nearly all of these countries, the authorities in charge of foreign investment have enjoyed regulatory powers, and as such have tried to produce specific data on the telecommunications sector. Rarely, however, have such initiatives been orchestrated in conjunction with a more general overview of research and innovation activities. Usually, basic statistics such as gross expenditure on research and development (GERD) come from estimates made by the ministry or council in charge of higher education or research. This does not inspire confidence in the data: these entities are reporting data that they themselves will be judged upon. Moreover since practically 70 per cent of the costs of research and development are public expenses, and these are largely channelled through central state budgets, ministries in charge of budgets and finance may not be inclined to release statistics on research expenditures either, since they only report budgets (that is, non-executed financial provisions given through the national budgetary procedures). Finally, some sources used in international statistics, for example COMSTECH data normally used by international organizations, are strikingly different from most other sources. The methodology used for collecting and analysing the data is not published. UNESCO, through its Montreal-based Institute of Statistics, has undertaken to validate data on the Arab region, an effort which can only be encouraged. The aim here is not only to provide more transparency regarding public statistical data but also to improve the confidence of non-public entities (in particular private companies) in reporting on research and innovation by the Arab States.

**Figure 4. Correlation between GDP and GERD to GDP ratio**




*Source*: Own calculation based on the dataset presented above.

*Note*: R=-0.293; p= 0.290 (p>0,01: not statistically significant).

There are discrepancies that may cast serious doubt on certain figures. For example, some countries report both high GERD and low contribution to education as a whole: this is the case for both the Sudan and Qatar. Great caution should be given to the use of one single indicator.

Gross expenditure on research and development (GERD) has been low in Arab countries for almost four decades and is lower than the world average at between 0.1 per cent and 1.2 per cent of gross domestic product (GDP). OECD countries devote about 2.2 per cent of GDP to research and development. There are signs of change however. Egypt's GERD has remained stable at about 0.23 per cent since 2007; prior to the outbreak of the revolution, the government had planned to raise it to 1.0 per cent over five years, and had engaged in reform of the governance of research and innovation based on more competitive funding, larger funding for research at public universities, and more active government structures. Although the revolution interrupted this reform process, it seems that these orientations for science and technology will be maintained. Something similar has happened in Tunisia. Prior to the revolution, Tunisia's GERD had been climbing steadily since 2000; in 2007 it was the leading Arab state for research and development intensity, at just over 1.2 per cent of GDP. It will probably maintain the advantage it has acquired over almost ten years of institutional modelling, given that, until now, the newly-elected Tunisian Government has not sought to challenge them.[48] Saudi Arabia, whose per capita GDP is the fifth highest in the region, adopted a national plan for science and technology in 2003. However, it was still ranked second-to-last in terms of research and development spending as a percentage of GDP, at 0.05 per cent, ahead of Bahrain, at 0.04 per cent.

There is no congruence between GERD and either GDP or GDP per capita. Indeed, investment in research is not linked to GDP in a simplistic, linear fashion. Some rich countries, such as the United Arab Emirates, do not invest proportionally in the development of science. This, however, relates more to the

[48] M'henni and Arvanitis, 2012.

capacity to spend, which is not related to GDP so much as administrative capabilities and institutions. In fact, the United Arab Emirates is among the countries with the highest growth in number of publications over the last ten years. This growth is not related to its very high GDP; much depended on the pro-research stance of the Government, political system, and ambient values, in particular with regards to religion, the historical connection to Great Britain, and international support.

Since authoritarianism has often forced Arab scientists to flee their countries, they end up contributing to the GDP of Western industrial States, rather than the States of the Arab region. However, the private sector and public companies in the productive sector also have part of the responsibility. Over the next three years, more than half of the companies surveyed for the Global Innovation Index survey expect to increase the level of their research and development investment in the Middle East. This result is slightly skewed, however, by the presence of foreign companies in the survey. Among those foreign companies, only around 40 per cent plan to increase their R&D investment in the region over the next three years. Public companies that are run as private businesses but have a real monopoly are also systematically under-investing in research. Following a review of Mediterranean countries, a working group on innovation in the MIRA project concluded that very few large companies report research and development activities; among them are Sonade in Tunisia, and Sonatrach and Cevital in Algeria.[49] Morocco seemed to be in a slightly better position, but in most cases this related to highly profitable companies exploiting natural resources. Leaving oil and petroleum resources to one side, Morocco's Office Chérifien des Phosphates (OCP), one of the largest phosphate producers in the world, invests 1 per cent of its sales in R&D (its sales have been estimated at around 7 billion USD per year). A large part of that investment is not related to internal research and development but to 'open innovation', which consists of contracting and outsourcing research. This example comes from a company with a comparatively favourable prospect for research and development; moreover, Morocco is sharply increasing research and development investments in very strategic areas, not limited to foreign investment.

Foreign investment is usually sought in order to improve research and development. In fact, when foreign companies invest in research and development, they do little for local technological upgrading. In Tunisia, foreign-owned enterprises have a negligible impact on the economy. The analysis of the innovation survey[50] shows that foreign companies do not invest in R&D; nor do they invest in innovation. More generally, and contrary to popular opinion, the same holds true for foreign direct investment. This has been the case for example in China, where more than 400 research centres belonging to foreign companies have opened. None of these appear to translate that investment into local technological upgrading, except in the value chains related to the companies that own the facilities.[51] Studies on the research and development strategies of large global companies tend to confirm this, and there is no reason why the Arab region would be an exception.

For the most part, research and development centres in the Arab region are relatively small and focus on late-stage development, rather than basic research.[52] Only recently have new initiatives and partnerships been established between the private and public sectors to promote research and development (box 1). Moreover, following some trials and tribulations, Maghreb countries have demonstrated that technology transfer units from universities to the productive sector are relatively inefficient. Most support given to research, development and innovation by national authorities is directed toward Small and Medium Enterprises, based on the claim that in the economies of the Arab region, SMEs form not only the bulk of companies (up to 95 per cent in most countries), but also provide most employment. This preference for SMEs has been the basis of 'upgrading programmes' from Mexico to Tunisia, and Chile to Thailand. The European Union has been very keen to fund these up-grading schemes in North Africa. The results are

[49] Khelfaoui, 2006.

[50] Gabsi et al., 2008.

[51] Bironneau, 2012.

[52] Economist Intelligence Unit, 2011, p. 4.

always far below expectations and it is usually claimed that the fault lies with the programmes and their management. After so many years of upgrading programmes, it is time for an alternative explanation. What is needed is a diversification of economic investment: support for large investment projects in highly competitive areas (even by providing direct support to large companies, something all large economies do on a permanent basis); strong support to innovative projects in smaller entities, whatever the sector, but with regularity and in rhythm with company growth; strong support for middle-sized (300 employee) companies with a proven record of technical success and economic strength, but insufficient investment capacity. Such policies would have a far better chance of success than the usual university-managed (and inefficient) technology transfer units or the small loans to tiny companies with no economic prospects.

From fieldwork done in many universities and technological poles or incubators, it appears that successful experiences, both entrepreneurial and innovative, are more numerous than is usually estimated. That was the conclusion reached by innovation surveys conducted in Morocco and Tunisia. Only the Egyptian survey on innovation found low levels of innovative activity and a more difficult economic environment than Maghreb countries.

The Arab Knowledge Report mentions a Jordanian initiative known as "A Professor in Every Factory" (launched in 2003), which sends academics into factories during the summer vacation. Another recent initiative, funded by a common EU-Jordan fund, is the 4 million euro scientific research and technological development (SRTD) programme, which funds innovation-related activities in the private sector. Most of these programmes have targeted small and medium enterprise.

A study on Jordan found a decent level of research and development spending in the private sector: 30 per cent, compared to 70 per cent for the public sector (this figure appears as the highest in ARAB countries). There is an incubator (called Oasis) of 500 with a proven record of transforming entrepreneurial ventures into viable businesses.[53] In Algeria, there are interesting examples from public companies which work in fields as varied as hydrocarbons, iron and steel, electronics, chemistry, and food and agriculture. Some have "centres for research and development" while others have only simple units of research. They have had in most cases a quite difficult conversion to R&D.[54]

In brief, when GERD is used as a measure of national scientific and technological advancement, the results for the Arab region are disappointing overall, despite the significant differences between countries. The annual share per Arab citizen of expenditure on scientific research does not exceed US$10, compared to the Malaysian citizen's annual share of US$33. In some small European countries such as Ireland and Finland, these figures are much higher, with annual expenditures on scientific research per capita reaching US$575 and US$1,304 respectively.[55]

### FOUNDATIONS FOR RESEARCH

A number of national funds for science, technology and innovation have been set up in recent years. These include the 2008 European Union-Egypt Innovation Fund, and three national funds: the Qatar Foundation, the Mohammed bin Rashid al-Maktoum Foundation in the United Arab Emirates (2007), and the Middle East Science Fund in Jordan (2009). Among them, only Qatar set the bar high by calling for the allocation of 2.8 per cent of the general budget to support scientific research in mid- 2008.[56] The establishment of the European Union-Egypt Innovation Fund in 2008 was intended to support projects for applied research on a competitive basis, with special emphasis on innovation.[57]

[53] SWOT Analysis of Jordan Science System, ESCWA (unpublished report).

[54] Khelfaoui, 2004, p. 80.

[55] UNDP, 2009, p. 193.

[56] Law N° 24/2008 regarding support and regulation of scientific research.

[57] Mouton and Waast, 2009.

## VI. SCIENTIFIC PRODUCTION

Usually scientific production is measured by indicators based on two types of data: the number of publications in refereed international scientific journals and books, and the citations received by published articles. Studying the use of citations is only possible using the Thomson Reuters Web of Science or Elsevier's Scopus. These two databases are the only ones containing citations. Specialized databases or other large multidisciplinary databases are usually not used in bibliometric analysis. The main reason is that a stable reference is required in order to do comparative analysis. From this point of view, the Web of Science is supposedly more stable than Scopus, although it has been shown that both deliver similar results. This holds true for large countries only, and for statistical analysis of fields with a large number of publications (because of the statistical size of the sample of publications). It is probably not true for the analysis of country-specific data, when these countries have small rates of scholarly production; that is, practically all Arabic countries.

Another issue with databases is their coverage of certain fields. It appears that they underestimate certain domains, while tending to overestimate others: for instance, the biomedical sciences are better covered by the Web of Science. Books and other forms of publication, more frequent in the social sciences and humanities, are badly covered by both databases (although they attempt to at least partially cover edited books). Every small journal in the United States is covered in the Social Sciences Index, but many widely-circulated journals outside the United States are missing; this is true for publications from Europe as well as from other countries and regions. The underlying model of Web of Science and Scopus is a commercial world centred in the United States, a model that has been challenged even for so-called 'hard' sciences.

The authors have looked at the case of the American University of Beirut in order to determine how much of its total scholarly production is reported by international databases. The example makes sense because AUB has a good level of publications in English in major journals. The unreported publication record can however be relatively high, even in the case of AUB.[58]

TABLE 7. GROWTH RATES AND COMPARISONS OF SOME ARAB COUNTRIES

| | Morocco | Algeria | Tunisia | Egypt | Jordan | Lebanon | Syria | Chile | Thai | South Africa |
|---|---|---|---|---|---|---|---|---|---|---|
| Scores SCI 2006[b/] | 756 | 728 | 1 079 | 2 743 | 421[a/] | 481[a/] | 146[a/] | 2 972[a/] | 2 235[a/] | 3 330 |
| Percentage World shares 2004[c/] | 1.26 | 0,73 | 1.08 | 3.42 | 0.69 | 0.48 | 0.16 | 3.04 | 2.43 | 4.64 |

*Source*: Science Citation Index (SCI) 2006.

* SCI 2005. Non expanded. Integer counts.

b/ Calculation P.L. Rossi/IRD.

c/ Calculation OST. In Arvanitis 2007 ESTIME Final Report.

### A. RAPID GROWTH OF SCIENTIFIC PRODUCTION

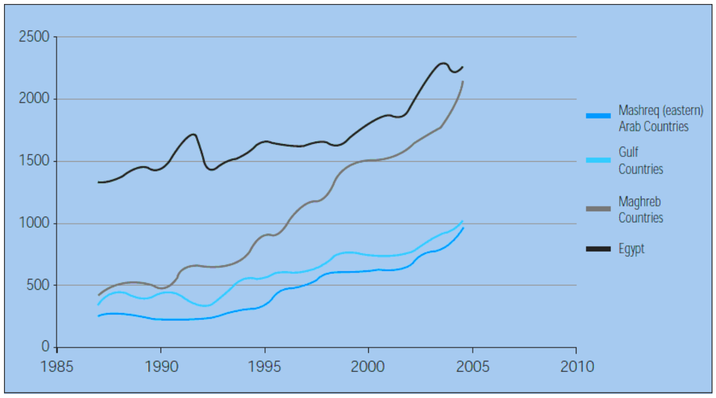
The total numbers of scientific articles is still low in Arab countries. A recent report indicates that in 2007, the number of Arab scientific publications (approx. 15,000 papers) was equivalent to the scholarly output of Brazil and South Korea in 1985.[59] Moreover, the number of articles published annually per 100 researchers was only 2 in four Arab countries; 6 and 38 in two further countries; and around 100 in Kuwait. If the total number of university teaching staff in the Arab region is calculated at 180,000, plus an additional 30,000 researchers working full-time in specialised centres, then the academic-scientific corps working in

[58] This is an on-going project. Results will be delivered by the end of 2014.

[59] Mrad, 2011.

Arab research and development can be estimated at 210,000 researchers. Yet these specialized scientists produce only 5,000 academic papers per year, equal to 24 scientific papers per 1,000 university professors and full-time researchers.[60]

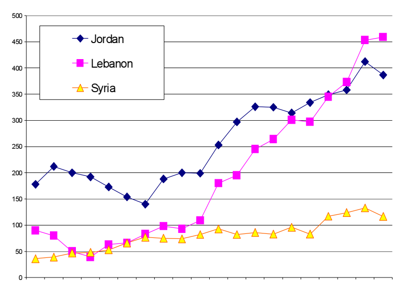
**Figure 5. Number of scientific papers published in the Arab region (1985-2010)**




*Sources*: UNDP and Al Maktoum Foundation, 2009, p. 196.

This is the result of the underinvestment in research that has already been mentioned above. What is reassuring, however, is the fact that growth over the last twenty years has been impressive. Growth rates are above the world average for publications, and comparable to three emerging countries: Chile, Thailand and South Africa. By contrast, the Arab region was invisible to computation some twenty years ago, representing a mere 1.5 per cent of world production.

**Figure 6. Scientific production of Middle Eastern countries (1987-2006)**



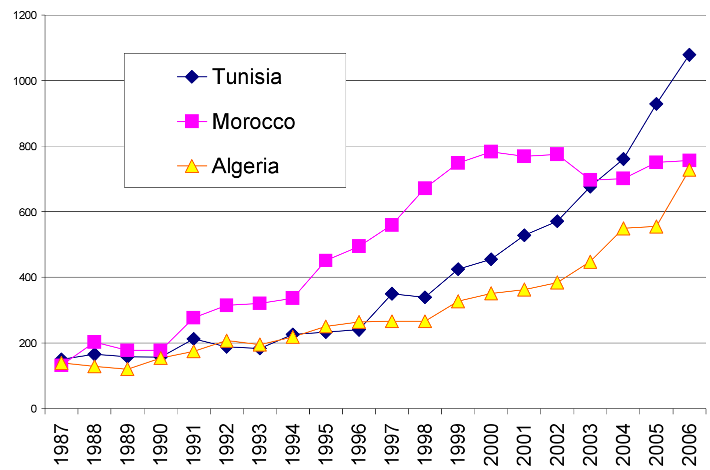

*Source*: Data SCI (non-expanded). Computing PL Rossi, IRD.

The main explanation is the extremely strong growth of the Maghreb countries. Tunisia has quadrupled its publications in less than a decade (from 540 in 2000 to 2026 in 2008), achieving a 2.05 per cent share of global publications. Morocco also had a very strong surge in production slightly earlier, between 1998 and 2004. Algeria has also undergone a recent rapid expansion, as well as Jordan, Lebanon, the United Arab Emirates and Saudi Arabia. Egypt experienced sluggish growth during the early 2000's, but experienced a surge in production over the last six years. The reason probably lies in the new effort to promote research, including a policy of investment in science. Funding has increased, alongside and opportunities to collaborate with foreign scientists.

[60] UNDP, 2009, p. 201.

In terms of book production, twenty Arab countries produce 6,000 books per year, compared to 102,000 in North America.[61] There are as many translations published annually in Greece as in all Arab countries.[62] This relatively low rate of production in the Arab region has been the topic of many discussions.

**Figure 7. Evolution of the scientific production of Maghreb countries (1987-2006)**




The cases of Egypt, Jordan and Tunisia show that a strong institutional change in the policy toward research funding seems to have triggered a real shift in production. More money distributed through competitive projects, international collaborative projects, and recognition of research activities seems to be a key feature in all these countries. The reason why this particular mix of funding instruments is functioning, will be the object of the concluding remarks of this report.

In the social sciences we have no good information sources for publications. There is, however, one notable exception, namely the Maghreb countries. In Casablanca, the Abdulaziz Foundation keeps relatively exhaustive records of production in the humanities and social sciences for all Maghreb countries. It also keeps track of publications in the humanities and social sciences produced elsewhere which focus on the Maghreb region. This very exceptional source of information has only been used once to our knowledge for bibliometric purposes.[63]

Figure 6 shows the growth pattern for the three main Maghreb countries. As can be seen, Morocco experienced a very sharp increase in its production between 1999 and 2004. The content of the database has been examined in depth. It should be noted that the growth of the social science production in Morocco has been probably as quick as, if not quicker, than the other fields of science that are best caught by the Thomson and Scopus databases. Moreover, the Abdulaziz database has demonstrated the highly differentiated forms of production in fields such as history, economics, sociology and anthropology. It indicated the dominance of the humanities (literature studies, philosophy and religious studies) and the surprising decline of publications on economics. This is even more surprising given that business management is among the most rapidly growing areas of study in practically all Arab countries.

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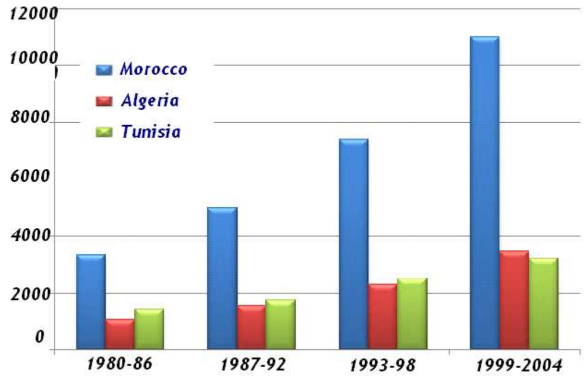
[61] Lord, 2008.

[62] Mermier, 2005.

[63] Waast et al., 2010.

**Figure 8. Academic publications in Maghreb social sciences and humanities (1980-2004)**

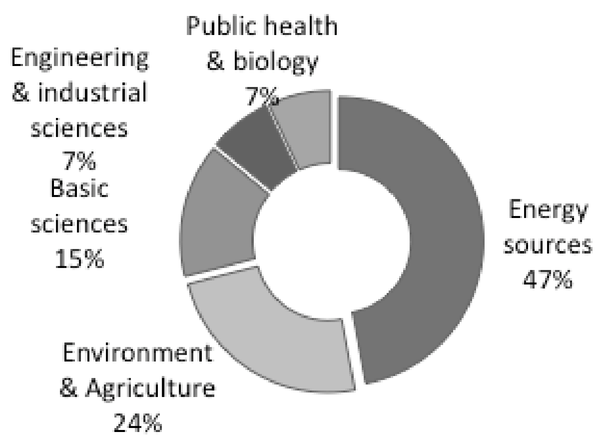



*Source*: *Fondation Abdulaziz,* Casablanca. Processing by IRD.

### B. A MARKED SPECIALIZATION PATTERN IN THE ARAB COUNTRIES

When looking at the distribution by areas of science we find a very particular mix of disciplines (figure 9). Energy sciences (engineering mostly) accounted for 47 per cent, followed by the environment and agriculture sciences with 24 per cent and basic sciences with only 15 per cent. Engineering in all senses is the dominant discipline in most Arab countries, with the notable exceptions of Tunisia and Lebanon. Egypt, Morocco and Algeria are all strong in chemistry, primarily organic chemistry, chemical engineering and physio-chemical characterisations of specific materials. Clinical medicine is a research strength for Jordan, Kuwait, Lebanon, Oman and Saudi Arabia, Tunisia and the United Arab Emirates. Syria's strength lies in plant and animal science, largely due to the presence of ICARDA, an international institute belonging to the Consultative Group for International Agricultural Research Centres, which is based in Aleppo. Qatar makes its mark in engineering.[64]

**Figure 9. Scientific articles according to domains (1998-2007)**

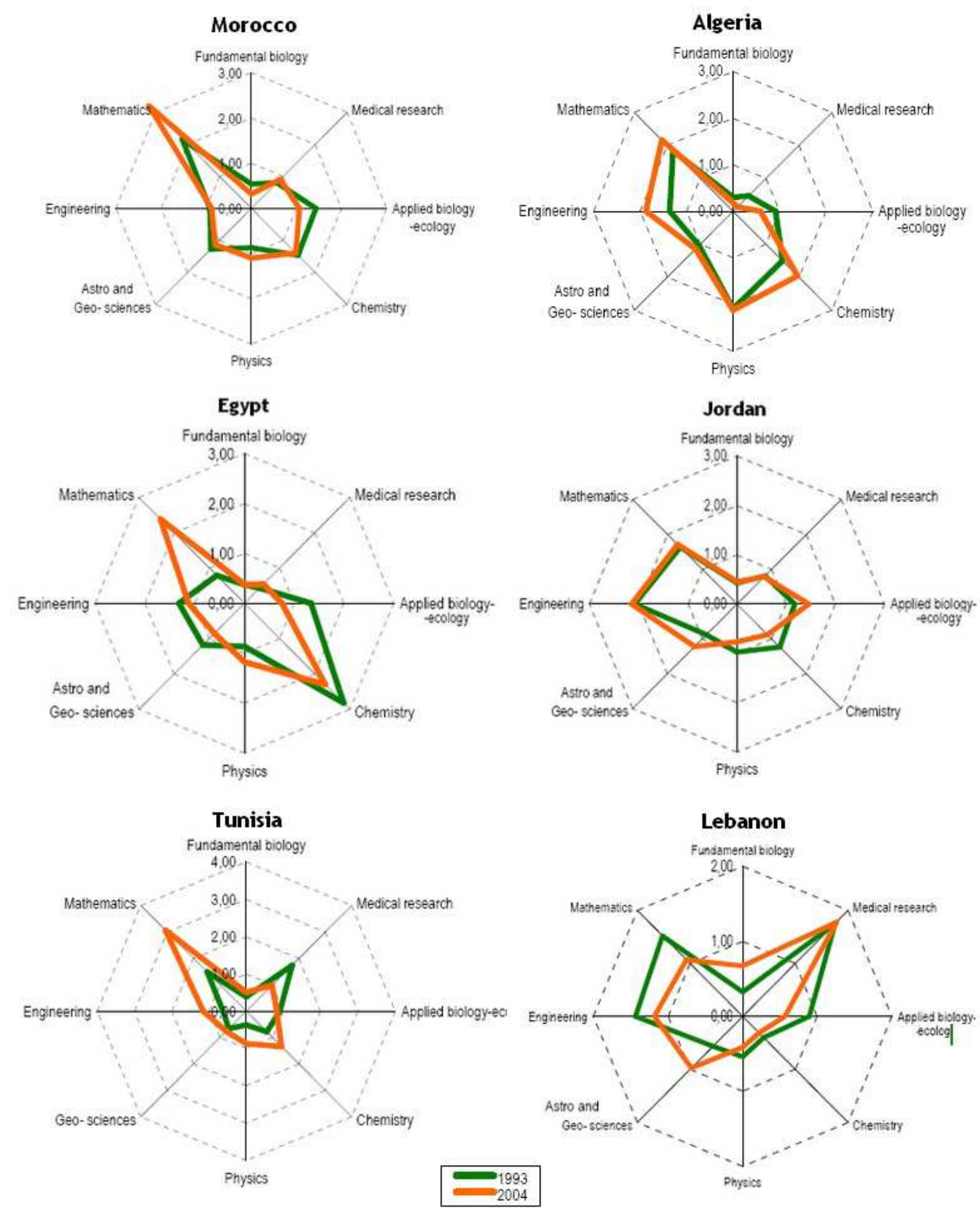



*Sources*: UNDP and Al Maktoum Foundation, 2009, p. 198; COMSTECH data source.

[64] Naim and Rahman, 2009, cited in UNESCO, 2010, p. 263.

Figure 10 shows the specialization patterns for six countries from 1993 and 2004, based on data from the Web of Science. In eight domains, the specialization patterns of these six countries are very similar over time. Two exceptions can be noted: a relative surge in mathematics in Egypt, although it should be noted that this still concerns a very small number of articles; and the relative growth in biomedical research in Tunisia. This has been the result of the growth pattern of scientific production of the country which has a strong emphasis in the biomedical domains.

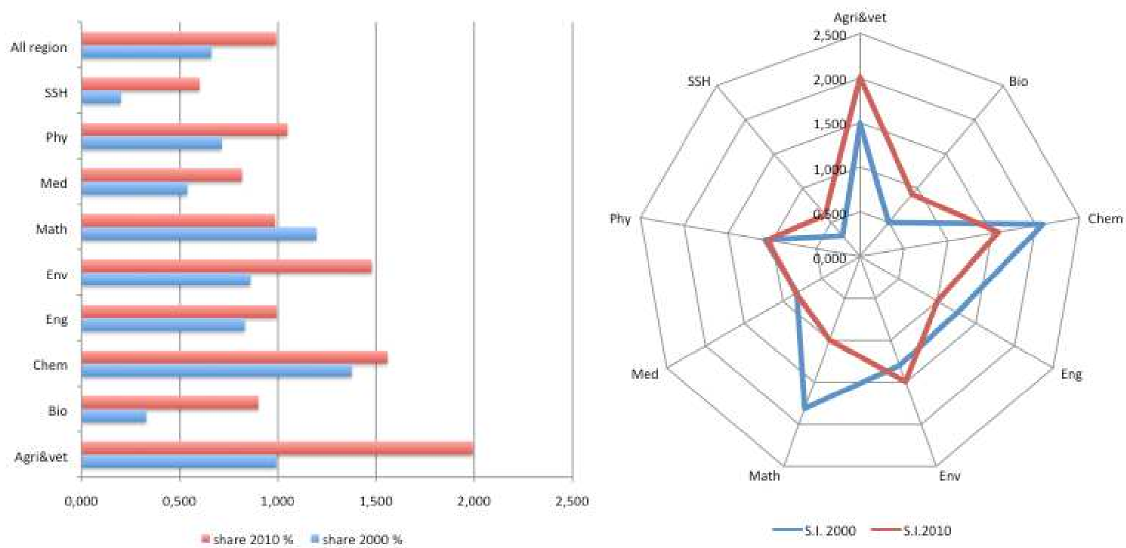
**Figure 10. Specialization patterns in six selected Arab countries (1993 and 2004)**




*Source*: Data Thomson ISI, SCI Expanded. Computing OST.

Tunisia has thus become closer in its production profile to Lebanon which, as can be seen in figures 10 and 11, is very different from other countries. The case of Lebanon is very special: it has a strong medical research core of two large hospitals, namely the American University of Beirut Medical Center and Hotel Dieu de France, both attached to large private universities (AUB and USJ). There is also a growing number of publications from the Lebanese University and Balamand University, which both have well-regarded university hospitals. Nonetheless, most of Lebanon's production in this area is affiliated with AUB and its Medical Center, which has historical prestige in the region. Moreover, AUB has made a strong effort to promote the scientific production of its personnel, which has translated into impressive overall production figures.

**Figure 11. Specialization pattern of ESCWA Arab region as a whole (2000-2010)**




*Source*: compiled by us based on Scopus from http://www.scimagojr.com/.

*Note*: Left graphic represents the share of ARAB countries in the domain. Right graphic represents specialization index. Specialization index=1 when activity in the domain is similar as the country's activity in the world production; above 1 there is a specialization in the specific domain; below 1 there is less specialization.

Jordan is moving in a similar direction, although from a typically engineering-dominated landscape of research. It is now evolving towards producing more research which will be based on a recognized medical capability. Nevertheless, the dominant figure in Jordan remains engineering-related areas of specialization.

The over-specialization in engineering might also partially explain under-production in Arab countries. It is well-known that engineering sciences produce lower overall figures of articles than biomedical and life sciences. Patterns of publication in engineering are also lower compared to basic sciences (chemistry, physics, biology). This is also true of agricultural sciences, which tend to have patterns of production closer to engineering than to basic sciences.

For an overview of other Arab countries, annex 1 shows the specialization patterns for Arab countries (percentage of publication in each specialty out of the total publications) for 2000 and 2010, as well as other indicators. In specialization profiles calculated on a different categorization of domains of research and Scopus data (instead of SCI), Tunisia and Egypt have seen the most important changes in the 10 intervening years: Tunisia has greatly increased its production in the agricultural sciences and diminished its specialization in mathematics. Egypt, primarily because the size of the production involved is more important, has considerably diminished its over-specialization in chemistry. This is a good sign, because in this particular case most publications on chemistry were routine analyses of specific chemico-physical characteristics of materials. Now, the country produces an evener spread of publications in various domains. It is also striking to note the similarity in the specialization profiles of Egypt and Saudi Arabia (low in medical sciences and biology, high in engineering). Finally, it is interesting to compare two countries that are very similar in size but have quite different profiles. Jordan has a stronger emphasis in engineering, environmental sciences and, surprisingly, social sciences. As a word of caution it should be mentioned that figures for social science disciplines are still relatively low (and probably more sensitive to changes in the specialization indicators). By contrast, Lebanon has stronger specializations in biological sciences, agricultural sciences and clinical medicine. Interestingly, there is a slowdown in medical specializations in Lebanon to the benefit of the biological sciences, a more basic set of sciences. This is probably a sign of a growing emphasis on research.

The overall pattern of specialization and growth for the Arab region, because of the importance of some countries in size (Egypt, Saudi Arabia, Algeria) is also very much geared toward the chemical sciences and agricultural sciences. As we see, the environment appears as a new domain of specialty, which we believe is influenced by increased funding for environmental sciences, primarily from Europe but also internationally.

### C. LOW CITATIONS, LOW IMPACT?

What is most striking is that figures of citations received by the publications in Arab countries are still low in comparison to those published in other regions of the world. Whereas the average number of citations for a single paper from the United States is 3.82 (one of the highest averages worldwide), and the average for a South Korean paper is 1.51, the average number of citations from the Arab region ranges from 0.99 for Lebanon to 0.60 for Egypt. The figure can be as low as 0.01 in other Arab countries. These very low figures of received citations do not reflect differences in language, since all the data pertains to English material published and reported by the Thomson and Scopus databases.

Citations measure influence, if not impact. They are closely related to the distribution of prestige and reputation in the scientific community. Even though they do not necessarily measure quality (as was claimed by the inventor of the citation measurement, E. Garfield), they do reflect the way in which the scientific community uses its publications. It should be noted that more than half of the world's science production is not cited at all. Since measures based on citations depend on time, many indicators have been proposed to take into account this factor. The H-index is one of the most popular measures, designed by Hirsch precisely in order to record this effect of age in relation to citations and publications. The logic behind the H-index is that the longer a career, the more likely citations become. One way to take this cumulative effect into account without giving it a decisive advantage is to detect the number of citations received in relation to the number of publications. The H-index, for present purposes, is the number of articles within a given country (H) that have received at least H citations. An H-index of "30" would mean that this country has 30 publications that all received at least 30 citations. To arrive at this result, the country in question would need to have far more than 30 publications. The index measures a certain level of permanence.

The issue here is that the H-index can vary widely, with some articles receiving a very high margin of citations. This is usually the case when an institution inherits the work of a large number of researchers that have been very productive in their former institutions, or associate researchers from other countries with very high citation scores. The H-index has several drawbacks, but it is especially problematic when used to measure publications on a collective, rather than individual scale – including measurements taken at the national level. The variety of publication and citation practices across fields is not correctly represented by this indicator, resulting in a situation where fields known to be highly productive, both in terms of papers and of citations, impose a global norm.

Nevertheless, this figure is rather low for Arab countries. For example, Scimago, which reports statistics calculated on Scopus data, reports H-indexes for the whole period 1996-2010 in table 10. By way of comparison, the United States (an outlier in all these statistics) has an H-index of 1,229, followed by the United Kingdom, with 750. Farther down are Germany (657), France (604), Canada (580), Japan (568), and Italy (412). For this 15-year period, the core countries of Europe have H-indexes between 20 and 30. Other middle-range countries have figures ranging between 20 and 35. China has a relatively low index of 53, meaning the number of papers that received a high flow of citations is low. It should be noted that the H-index is indeed sensitive to the scale of production (the more articles are produced, the greater the probability of high flows of citations), longevity and regularity.

TABLE 8. SCIENTIFIC PRODUCTION AND THE H-INDEX
(1996-2010)

| Rank | Country | Citable documents | Citations | National citations | Citations per document | H index | Rank H-index |
|---|---|---|---|---|---|---|---|
| 40 | Egypt | 63 415 | 367 134 | 78 841 | 6.79 | 115 | 48 |
| 50 | Saudi Arabia | 35 161 | 200 216 | 28 678 | 6.42 | 106 | 55 |
| 52 | Tunisia | 25 780 | 116 113 | 27 106 | 6.37 | 75 | 75 |
| 55 | Morocco | 19 721 | 116 525 | 21 795 | 6.48 | 84 | 67 |
| 59 | Algeria | 17 288 | 71 453 | 14 240 | 6.01 | 68 | 84 |
| 61 | Jordan | 14 477 | 74 534 | 11 684 | 6.38 | 66 | 87 |
| 66 | United Arab Emirates | 12 372 | 68 035 | 8 154 | 7.02 | 72 | 76 |
| 67 | Kuwait | 10 723 | 69 937 | 10 457 | 7.06 | 71 | 80 |
| 69 | Lebanon | 9 319 | 69 103 | 7 321 | 8.98 | 82 | 72 |
| 82 | Oman | 5 488 | 30 617 | 3 987 | 6.64 | 52 | 98 |
| 95 | Qatar | 3 286 | 13 450 | 1 326 | 5.07 | 39 | 127 |
| 97 | Iraq | 3 147 | 9 345 | 1 084 | 4.24 | 31 | 148 |
| 99 | Syrian Arab Republic | 2 827 | 21 004 | 2 874 | 9.01 | 50 | 104 |
| 102 | Sudan | 2 693 | 17 692 | 2 602 | 8.5 | 45 | 114 |
| 108 | Bahrain | 2 304 | 9 257 | 1 051 | 4.72 | 33 | 141 |
| 111 | Libya | 1 944 | 5 996 | 385 | 4.5 | 29 | 154 |
| 113 | Palestine | 1 787 | 9 374 | 1 511 | 7.34 | 35 | 134 |
| 127 | Yemen | 1 093 | 5 894 | 691 | 6.96 | 32 | 147 |
| 168 | Mauritania | 250 | 1 893 | 96 | 8.17 | 22 | 167 |
| 191 | Djibouti | 79 | 464 | 19 | 6.21 | 11 | 200 |
| 206 | Somalia | 42 | 233 | 3 | 7.82 | 10 | 204 |

Table 10 confirms this analysis and shows not only the low figures of countries but also two countries with “irregular” behaviour with respect to this citation indicator. The first, Lebanon, has a much higher H-index than expected. This is due to high production in the biomedical fields and reflects a real engagement in internationally recognized research. The United Arab Emirates also demonstrates a higher-than-expected H-index. For many reasons, the Emirates have engaged in what seems to be progress towards internationally recognized research. These high figures could also be the result of growing numbers of expatriates in United Arab Emirates.

## D. ISSUES RELATED TO IMPACT

The most famous bibliometric indicator is the impact factor, which measures the mean number of citations received by a journal compared to the total number of articles published by the journal. It is very different from one field to another, is not very robust (and thus varies significantly), and has many statistical difficulties. There has also been a fierce controversy regarding the use of the impact factor, which is in part due to the availability of the indicators regularly published by the Thomson Web of Science (in its science citation index reports), and which have existed since Garfield introduced it in the 1960’s. Finally, the impact factor is based on a generalization of the citations received by a journal and can therefore be easily manipulated by an unscrupulous journal editor.[65]

[65] Monastersky, 2005.

Citation measurements have encouraged a certain concentration of production into journals that are registered in the Web of Science database, which were once thought to represent "mainstream science". This poses a real difficulty to countries lacking a significant history of scientific publication, since the game seems strictly limited to a very small number of players.

The real difficulty for Arab countries is that pressure for publishing in these very few "internationally recognized" journals discourages production in local journals.[66] Arab science periodicals included in international databases number no more than 500, about a third of which are published by Egyptian universities and research centres; the other two-thirds are divided between Morocco, Jordan and Iraq. Arab science journals suffer from fundamental problems such as irregular publishing, lack of objective peer review and the unedited publication of the proceedings of conferences and seminars. Additionally, some of these periodicals are not regarded as credible for academic promotion purposes, leading many researchers and academics to prefer publication in international, peer-reviewed journals.[67]

TABLE 9. LOCAL JOURNALS IN DATABASES
(*Countries around the Mediterranean Basin*)

| | Scopus | SCI+SSCI[68] + A&HCI[69] (WoS) |
|---|---|---|
| Spain | 356 | 163 |
| France | 770 | 251 |
| Monaco | 3 | 0 |
| Malta | 1 | 0 |
| Italy | 572 | 168 |
| Slovenia | 29 | 25 |
| Croatia | 104 | 62 |
| Bosnia- Herzegovina | 2 | 4 |
| Montenegro | 0 | 0 |
| Albania | 0 | 0 |
| Greece | 39 | 18 |
| Turkey | 143 | 73 |
| Syria | 0 | 0 |
| Cyprus | 2 | 0 |
| Lebanon | 4 | 0 |
| Israel | 70 | 25 |
| Egypt | 14 | 3 |
| Libya | 0 | 0 |
| Tunisia | 2 | 0 |
| Algeria | 1 | 0 |
| Morocco | 1 | 0 |
| Total | 2 084 | 792 |

*Source*: Analysis provided by Bülent Karasözen (not published data, 2010).

This issue of publishing is a very fundamental one and therefore should be made the object of a more systematic analysis. It should be just reminded that the lack of local journals in the Scopus and Web of Science databases is partly responsible for the low figures. The inclusion of journals, however, is usually based upon two conditions regularity and good. A researcher recently conducted a census of publications in the two databases that are produced in countries bordering the Mediterranean (table 9) and found a decent amount of local journals in countries where the research system is consolidated. A large country like Turkey

[66] Hanafi, 2010.

[67] UNDP, 2009, p. 200.

[68]Social Sciences Citation Index.
[69]Arts & Humanities Citation Index.

now counts 143 journals in Scopus and 73 in Web of Science. It should be underlined that many of these journals publish in English or are publishing at least an English summary. Maghreb countries, Egypt, Lebanon have very few journals. Quality cannot be only held responsible for this situation.

### E. International scientific collaborations

As a result of the growing complexity of science, the ease of face-to-face contact, the Internet, and government incentives, S&T activities are being conducted in an increasingly international manner. The indicator most often used to capture the scale or intensity of international collaboration in S&T is co-publications of authors from two or more different countries. Co-publication analysis can tell us something about the relative importance of international collaboration that leads to tangible outputs (publications) and the nature of the cooperation in terms of countries and disciplines.[70]

As has been reported by Gaillard and Arvanitis,[71] 30 per cent of the world's scientific and technical articles had authors from two or more countries in 2006, compared with slightly more than 10 per cent in 1988. One-quarter (26.6 per cent) of all articles with American authors had one or more non-American co-author in 2006; the percentage is similar for the Asia-8 group of countries,[72] and slightly lower for China and Japan (NSF and OST, 2008). Between 2001 and 2006, international co-publications increased in all countries except China, Turkey and Brazil. The higher rate for the fifteen key members of the European Union (EU-15), at 36 per cent in 2006, partly reflects the Union's emphasis on collaboration among member countries as well as the relatively small science base of some European Union members. The high level of collaboration among all other countries (46 per cent in 2006) may reflect science establishments that are small (for example, in developing countries) or in the process of being rebuilt (as is the case in Eastern Europe).

It is acknowledged that developing economies have high and increasing co-authorship figures; the smaller the country, the higher this proportion of co-authorship.[73] Co-authorships tend to be proportionally lower for larger countries with a growing scientific community. Thus in China, Brazil and Turkey, the number of co-authorships has fallen as a percentage of total production, a result of rapidly-growing scientific production and the diversification of scientific communities.

Table 10 presents data on overall scientific production in 2000 and 2010 alongside the corresponding shares of co-publications. As can be seen, co-authorship is extremely high for small producers (including the United Arab Emirates, the Syrian Arab Republic, Qatar, Libya, Yemen, the Sudan and Mauritania) while larger producers fall in the mid-range. Egypt has an exceptionally low figure of co-publications. However, the share of co-authorships is expected to grow in Egypt, as in other countries. The standard situation for most Arab countries appears to be a rate of co-authorship accounting for approximately half of all publications.

### F. Publishing outside the international journals: Invisible knowledge

There is a tendency among all Arab public and private universities to adopt the American promotion system, which can be summarized with respect to scientific research as placing emphasis on publication in refereed international scientific journals.

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[70] See for instance Glänzel, 2001; Adams et al., 2007; Schmoch and Schubert, 2008; Mattsson et al., 2008.

[71] Gaillard and Arvanitis, 2010.

[72] The Asia-8 is composed of South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan and Thailand.

[73] Gaillard, 2010.

Authors are generally encouraged to make the decision about where to publish based on the impact factor; this has consequences for both the publications and the prestige of regional universities.

In order to understand how a university department's publications are distributed, we studied the amount and type of production of publications accounted for by the international databases, as well as those not covered by them. We took the example of AUB, a university that is typical in the sense that it has an explicit policy of encouraging its professors to publish in high-impact journals. We examined the total production of knowledge by AUB's professors in many forms (articles, books, manuals) from 2006 until 2010. We discovered that the Web of Science and Scopus databases only capture 31 per cent of the publications reported by professors in the annual reports of the Faculty of Arts and Sciences and in the Faculty of Agriculture at the American University of Beirut.

TABLE 10. PUBLICATIONS AND CO-AUTHORSHIP IN ARAB COUNTRIES (2000-2010)

| Country | Documents 2000 | Documents 2010 | % Int. Collaboration (2000) | % Int. collaboration (2010) | Share (%) World (2000) | Share (%) world (2010) |
|---|---|---|---|---|---|---|
| Saudi Arabia | 1 835 | 5 739 | 26.1 | 56.2 | 0.15 | 0.26 |
| Egypt | 2 858 | 8 459 | 28.1 | 40.2 | 0.24 | 0.4 |
| Bahrain | 89 | 266 | 15.73 | 42.48 | 0.01 | 0.01 |
| Iraq | 91 | 724 | 16 | 30 | 0.01 | 0.03 |
| Jordan | 627 | 2 062 | 30.46 | 41.46 | 0.05 | 0.09 |
| Lebanon | 448 | 1 259 | 38.4 | 54.6 | 0.04 | 0.06 |
| Kuwait | 568 | 1 050 | 27.9 | 45.7 | 0.05 | 0.05 |
| Oman | 255 | 779 | 42.4 | 60.7 | 0.02 | 0.04 |
| Palestine | 40 | 281 | 50.0 | 50.9 | 0 | 0.01 |
| Qatar | 58 | 693 | 34.5 | 69.6 | 0 | 0.03 |
| Syria | 139 | 402 | 52.5 | 62 | 0.01 | 0.02 |
| UAE | 425 | 2 059 | 47.5 | 58.2 | 0.04 | 0.09 |
| Yemen | 41 | 198 | 68.3 | 70.2 | 0 | 0.01 |
| Sudan | 99 | 466 | 55.6 | 59.2 | 0.01 | 0.02 |
| Algeria | 495 | 2 862 | 51.5 | 52.5 | 0.04 | 0.13 |
| Libya | 72 | 468 | 34.7 | 51.9 | 0.01 | 0.02 |
| Morocco | 1 184 | 2 277 | 51.4 | 47.6 | 0.1 | 0.1 |
| Tunisia | 755 | 4 415 | 39.7 | 43.9 | 0.06 | 0.2 |
| Mauritania | 14 | 20 | 78.6 | 100 | 0 | 0 |

*Source*: Scimago, based on Scopus data. http://www.scimagojr.com/.

The rest is thus 'invisible' to the databases, but may be visible outside the academic community. It may also relate to local uses and local communities where researchers live. Perhaps this tendency (conscious and unconscious) to separate the university from community plays an important role in marginalizing the university or, rather, separating it from local society.

As expected, the proportion of invisible knowledge in the humanities and social sciences was found to be very high (88 per cent and 81 per cent, respectively), and lower for applied sciences (66 per cent); it amounts to one-third of publications on the basic sciences. Thus, the issue is not confined to the social sciences and humanities, but in all sciences with varying degrees.

## G. DISCUSSION

There are many reasons for the relatively low production of knowledge on science in the Arab countries. The reports that have previously studied the subject mention many of these, discussed below.

- *The role of the university promotion system*

Most researchers in the Arab region belong to higher education institutions. The promotion system used by these institutions profoundly affects the production of faculty members. In the best cases, the recruitment and promotion systems mention the necessity to present a certain number of publications; in many cases, the system is not so clear and no such rule is made explicit. One issue worthy of notice is the type of documentation required as evidence of production. Another issue is the balance between publications and other types of activities.

- *The research policy of higher education institutions*

Many professors would probably engage in more research if their institution relied on an explicit statement favouring research, which is rarely the case. Moreover, a research policy congruent with international tendencies requires a certain analytical capability that is rarely found at the university level.

- *The lack of high-quality Arabic science journals*

Local journals published in Arabic are rare. Local periodicals of good scientific stature should be encouraged, not as academic department information papers but as relevant disciplinary ventures. This would promote the image of science in society; it would help young researchers to publish their work, and provide a venue for the diffusion of local scientific activity. Certain common pitfalls are to be avoided, such as irregular publication schedules, a lack of objective peer review, and irrelevant topics to the local society.

- *The need for a systematic analysis of research programme impact*

A notable effort is being made to create observatories and indicators in science and technology in the region. An effort should be made to tackle the issue of impact of research and the role of publications. Some guidelines have been provided in the white paper produced following a series of expert workshops as part of the MIRA project.[74]

[74] MIRA, 2011.

## VII. SPECIFICITY OF SOCIAL SCIENCES RESEARCH

This section raises two points: the first concerns the place of production of the social sciences. The second concerns the status of social sciences in the Arab region, and the attempt to delegitimize them.

### A. PLACE OF PRODUCTION OF THE SOCIAL SCIENCES

All Arab countries, with the exception of Gulf monarchies, invest in social research with the help of international aid. Research is done either by universities or research centres, but Arab countries that create a hospitable environment for research are rare. Political repression, censorship and lack of research-based policy hinder the development of such environments.

Scholars from the Maghreb involved in the ESTIME project clearly indicated that the phenomenon of research centres, taking the form of NGOs, is not very widespread. However, the case in the Arab Mashrek is quite different. Research centres, whether private or as NGOs, are flourishing, launching several surveys in applied social research for two particular reasons: the first being the peace processes of both Lebanon (after the Taef Agreement of 1989) and Palestine (following signature of the Oslo Accords in 1993), and the second concerning economic liberalization in Jordan and Egypt. The keyword for the donors was "the empowerment" of civil society. These centres produce either research or pure consultancy, i.e. perfunctory research with the output often consisting of an unpublished report.[75]

The survey carried out in the mid-2000's by Sari Hanafi concerning research centres in the Arab Mashrek shows that research activities have mainly been conducted by two different types of organizations: first, by specialized research organizations such as research centers that have emerged either within or outside university settings (like The Lebanese Center for Policy Studies), and second, by NGOs specialized in development, advocacy and cooperative efforts. For instance, in the Palestinian Territory research production is very marginalized when it comes to university affiliated institutions (only four centers constituting 10 per cent of research output),[76] while the majority of organizations conducting research are NGOs. Some 41 per cent of the organizations producing research are specialized bodies, while the rest are NGOs dealing with advocacy and development.

However, there are two exceptional cases in the region: on the one hand, Lebanon and the Syrian Arab Republic; on the other hand, Egypt. In Lebanon, the university is still the bastion of research: according to the ESTIME survey, 85 per cent (60 out of 71) of the researchers included were affiliated with Lebanese universities.[77] The Syrian Arab Republic has a similar profile, but for different reasons: the Government still controls what is produced in the social sciences and humanities. These are strongly apologetic, restricted in their research approaches, controlled by single-party authorities, and used for ideological propaganda and political manipulation. Egypt constitutes a unique case where the importance of public research centres in the social sciences is a phenomenon that dates back to the 1950s. Egypt hosts the National Centre for Sociological and Criminological Research (NCSCR) based in Cairo, as well as the semi-public Al-Ahram Centre for Strategic Studies. Other centres are university affiliated, like The American Research Center in Egypt (ARCE), which is also based in Cairo.

In Jordan we find a diverse array of research organizations, but more importantly, the sweeping majority of these organizations are located outside the premises of universities.

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[75] IFPO and ESTIME established a database in 2005 for research centres and researchers. Among the 54 centres, there are 27 which publish 'grey literature': "En général les ONGs éditent soit des guides, pour celles qui sont très proches du terrain et font de la formation, des rapports et enquêtes, les universités des actes de colloque". (IFPO, 2007).

[76] Three are connected to Birzeit University (the Public Health Institution, the Law Centre and the Birzeit Centre for Development Studies) and one is connected to Al-Quds University (the Jerusalem Studies Center).

[77] IFPO, 2007.

Maghreb countries show the highest output of social and human sciences research, whereas Egypt and the countries of the Arab Mashrek are characterized by relative stagnation in these fields.[78] Taking the total number of projects supported in all fields in Lebanon, for example, we find that support for projects in human and social science research did not exceed 9 per cent at the American University of Beirut, and 5 per cent at the National Council for Scientific Research. The situation is comparable for most Arab countries. The reason for this may not lie in a lack of financial or human resources or in the absence of research priorities tied to the daily concerns of members of society, but rather in the weak academic incentives for researchers and university professors, especially in the fields of human and social sciences.

Although universities continue to play a primary role in social science research in the Maghreb, the Syrian Arab Republic, Libya and Lebanon, more than 80 per cent of social science research is produced through research centres or consultative agencies outside of universities, especially in Palestine, Jordan, and Egypt, and to some degree in the countries in the Gulf.[79]

### B. ATTEMPTS TO DELIGITIMISE THE SOCIAL SCIENCES

The authoritarian political elite, as well as some religious authorities, have seized on the problematic origins of social science disciplines (emerged during the colonization era and its foreign fundings) as a way of delegitimising them. It is rare in the Arab region to hear of a 'white paper' written by social scientists at the request of the public authority and debated in the public sphere. Sociologists are working either as elements in the matrix of modernization projects, though not as an independent body, or as servile agents restricted to justifying the Government's decisions. Principled social scientists have been sent to prison, exiled or assassinated. An intelligence officer once told one of the authors: "All of my group [of dissident social scientists] fill less than one bus and can easily be taken to prison!". Generally speaking, Arab authoritarian States have always underestimated the salience of such "bus people", whether defined as dissident intellectuals or more generally the enlightened middle class, in stirring protests. The 2011 Revolutions in Tunisia, Libya and Egypt served to confirm this view.

Religious authorities have often felt threatened by social scientists as the two groups competed over the discourse on society. An example from Sari Hanafi's 1994 study on family planning in the Syrian Arab Republic, revealed tense television debates involving a religious leader and an activist: Sheikh Mohamed Said Ramadan al-Bouti (who argued that Islam is against any form of family planning); against an anti-clericalist activist from the General Union of Syrian Women, a state-sponsored organization. While family planning falls squarely within the domain of sociology and demography, no social scientists were ever consulted for these public debates.

This delegitimization is reinforced by the way social scientists conduct their analysis. Producers of social knowledge in both the West and the Arab region create what is sometimes called the "mythology of uniqueness" of the Arabs. The Arab region was thought of as a place of cultural specificity and exceptionalism; Muslim immigrants to the West were similarly viewed as an incompatible ontological category predicated on culture.[80] Many still persist in seeing Arab societies as either a collection of religious devotees or segmented tribal groups. This exceptionalism has distracted from the real debate on societies, politics and culture in the Arab region,[81] especially in terms of the analysis of social class. Samir Kassir called this the "Arab Malaise",[82] resulting in a situation where, instead of studies of Muslims or Arabs, there are studies of Islam and Arabic.

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[78] El Kenz, 2005.

[79] UNDP, 2009, p. 202.

[80] Yilmaz, 2012.

[81] Kabbanji, 2011.

[82] Kassir, 2004.

**Box 2. The Tumultuous development of social science in the Arab region**

"The essential task of Arab sociology is to carry out critical work within two threads: (a) to deconstruct concepts that have emerged from the sociological knowledge and discourse of those who spoke on behalf of the Arab region, marked by a predominantly Western and ethnocentric ideology; and (b) to simultaneously critique the sociological knowledge and discourse on various Arab societies produced by Arabs themselves". (Khatibi, 1975, p. 1) [author's translation.].

This quote suggests a problematic relationship between the heritage of the Western social sciences and local Arab societies. We join Alain Roussillon (2002) who argues that sociology in the Arab region was part of the colonial project. Orientalist texts such as the five volumes of the nineteenth century *Description de l'Egypte,* produced by academics travelling with Napoleon's invading army, are illustrative. In the late colonial period and after the independence of the Arab States, an indigenous sociology or *sociologie musulmane* emerged. It attempted to decipher the specific nature of the segmented Arab Society and yet partially retained an Orientalist position, by investigating its own culture as "exotic". Nonetheless, sociology developed in close relation with the development of the national project.

Only since the 1970's have fragmented social science groups emerged in the Arab region. Politically, these groups have been in agreement with French and to a much lesser extent American social science. They were involved in the service of a political process, namely the engineering of a new society. The fundamental issue for social scientists after independence, and this is true for all postcolonial societies, is how to serve the State, the nation, or the modern project pursued by the nation. This project, whether communist, socialist, nationalist, or even pro-American, was concerned with the country's need for a modern administration and economic sector. This absorbed the social sciences into resolving technical problems, rather than being critical of them.

## VIII. NATIONAL SYSTEMS OF INNOVATION

As mentioned in the introduction of this report, innovation is distinct from research, and not all innovation is research-based. This is why innovation requires special attention, separate from but related to research. Innovation policies have been developed and sustained quite firmly over the last few years by some Governments, for example in Algeria, Egypt, Turkey, Morocco and Tunisia. Other countries have also promoted specific schemes and measures for innovation (Jordan, Lebanon, and, to a lesser degree, the Syrian Arab Republic). Gulf countries have also established specific measures. It should be added that, within the framework of the Barcelona process for European-Mediterranean cooperation, the European Union has also suggested more innovation-related actions in the hope of setting up a "Euro-Mediterranean Innovation Space" (EMIS).[83] Many international organisations, bilateral donors and NGOs have sought to assist in the transformation of Arab countries' development models from low-cost to knowledge-based production: the EU, the OECD, UNESCO, UNIDO and ALECSO are only a few examples. Finally, the World Bank has actively promoted the policies in favour of knowledge and innovation.[84]

A specific emphasis was placed by funding agencies and Governments on the development of techno-parks and industrial clusters.[85] This policy shift toward innovation (rather than solely research support) was basically done through measures promoting innovation in the public sector and contacts between the public and private sectors in many forms: engineering networks; technology transfer units; fiscal measures; and funding for start-ups and venture capital. Finally, to varying degrees, all the countries of the Arab region were profoundly affected by the example of the European Union in its promotion of innovation and the instruments it established to measure it, such as the European Innovation Scoreboard.

In Western industrial countries and those with growing industrial economies, there is a positive correlation between the country's position on an 'innovation index' and the growth of their gross domestic product (GDP). Arab countries, however, do not show such a positive correlation between GDP and innovation.[86] Despite the high GDP in oil-producing Arab countries, the ranking on the innovation and scientific research index of some of them remain low in comparison to other Arab countries with lower incomes (see the Innovation System Index for 17 Arab countries comparison between 1995 and 2008).

Innovation is not yet part of S&T parlance in the region. This may be attributed to the weak linkages overall between private and public R&D, as evidenced by the low output of patents (table 15). However, science parks were recently established in several Arab countries, including all of the monarchies of the Gulf. In these cases, the parks formed part of a broader policy of promoting enterprise and partnerships in innovation and research between the private and public sectors. This helps to explain the relative optimism of business executives interviewed about innovation in the Gulf for the World Bank Survey. These executives were particularly enthusiastic about prospects in Qatar and Saudi Arabia, which were ranked 11 and 21 respectively out of 142 countries. However, this indicator is analytically very weak as it depends on subjective criteria (the opinion of the business executives). Science parks have also been developed in the Maghreb, mainly in Tunisia and Morocco. For Tunisia, it has been a systematic policy to promote what it calls technopoles. In Morocco, some initial difficulties in establishing successful science parks have recently begun to give way to results. A first appraisal of science parks in Morocco and Tunisia concludes that it is too early to draw conclusive observations.[87] Nevertheless, they have undoubtedly contributed to the creation of new companies, and in some cases the creation of very successful medium to large companies. Most of these parks function as nurseries and incubators as well as technopoles. Lebanon has what is probably one of

[83] Pasimeni et al., 2006, p. ii.

[84] Reiffers, 2002.

[85] Saint Laurent, 2005.

[86] Mouton, 2009.

[87] Arvanitis and M'henni, 2009.

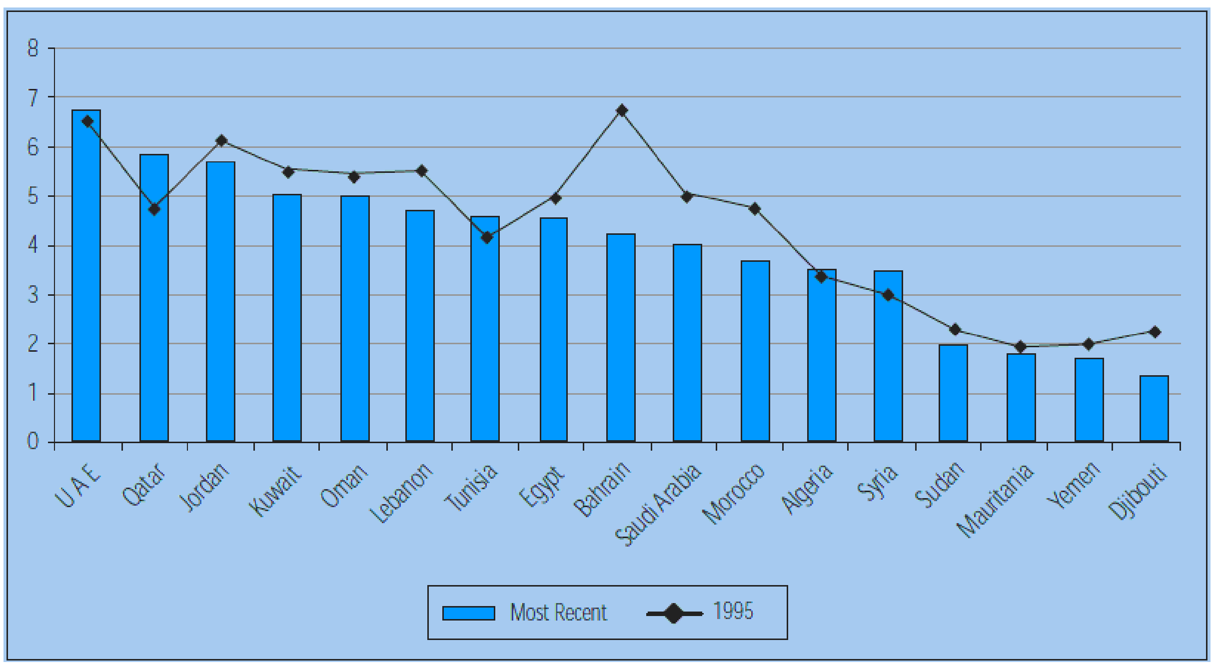
the most successful such initiatives, called Berytech, which has emerged as a private initiative of Saint-Joseph University's School of Engineering (box 4).

In 2009, Jordan launched El-Hassan Science Park as part of a major science project in Amman, and Egypt established its own Mubarak Science Park (which has since changed its name) (UNESCO, 2010b, p. 256). These experiments have been extremely slow to come about and will probably need to be revamped in the future.

King Abdulaziz City for Science and Technology (KACST) is a most interesting example (box 5).

What is compelling about KACST's model is that it is driven by local expertise, in contrast to what has happened in the United Arab Emirates and Qatar. However, when it comes to the social sciences, things can be different. Qatari authorities protected themselves from conservative political and religious commissars by asking the Qatari branches of the foreign universities to teach the same curriculum as their program at the university headquarters. In a recent interview, the President of Carnegie Mellon University Qatar stated that the Qatari authorities were responsible for the university's curriculum. The major issue at stake is to what extent the absence of freedom of expression in these countries affects this emerging model. The development of a "space for science" could become an extra-territorial space of exception, in the sense that local laws do not necessarily apply to it, bestowing the freedom to criticise the surrounding society, but also connect to it and respond to its needs.

**Figure 12. Innovation System Index for 17 Arab countries**




*Source*: UNDP and Al Maktoum Foundation, 2009.

**Box 3. Berytech**

Berytech was created in 2001 by Saint-Joseph University. It is one of the leading technopoles in Lebanon and the region. It seeks to provide a conducive environment for the creation and development of start-up businesses, hence retaining graduates and highly skilled Lebanese who might otherwise emigrate for the sake of their careers. Berytech started with one technopole in Mar Roukos and added a second pole on Damascus Road in 2007. It created its first US$6 million venture capital seed fund for Lebanese technology start-ups in 2008. Several entrepreneurial activities were introduced: Incubation Awards; entrepreneurship contests; summer schools and regional academies for entrepreneurs; "From idea to start-up" courses for engineers; Micro-Enterprise Acceleration Programs; university road shows; local and international exhibitions and workshops; entrepreneur forums; start-up weekends; mentoring programs; and networking events, among other activities.

To date, Berytech has housed more than 170 entities, assisted more than 2,000 entrepreneurs in several outreach programs, disbursed more than US$350,000 in grants to start-ups, and invested more than US$5 million in Lebanese technology companies. It was among the first such institutions in the region to receive accreditation from the European Union as a Business Innovation Centre, opening access to international networks for its companies and affiliates. In 2012, and with the support of the European Union, Berytech launched the Beirut Creative Cluster, grouping more than 30 leading companies in the multi-media industry, and was the European Bronze Label for Cluster Management Excellence.

More information is available from http://www.berytech.org.

A first appraisal of innovation policies in some Arab countries has concluded that measures to promote innovation cannot be evaluated properly because of the lack of comparative standards.[88] Direct measures to promote innovation through SME-oriented programmes, technoparks and incubators are easy to measure: however even this is not done, in particular because statistics on the productive sectors are not sufficient. What is also appearing after more than 10 years of systematic efforts in various countries is that policies have usually been short-term and success is expected to be easy and immediate and long-term efforts are not encouraged. Examples like the Berytech incubator in Beirut or the El-Ghazala technopark in Tunis are thus quite exceptional for having survived beyond the short-term. It is interesting to note that Berytech owes its extraordinary longevity and success to the fact that it benefits from autonomous management based on the permanent institutional support of a university; meanwhile, El-Ghazala owes a great part of its longevity to the existence of the School of Telecommunications, even though the companies inside the technopark do not have linkages with the school as strong as might be expected. In both cases, support is not financial but rather consists of the provision of an institutional background. These two examples in what can probably be considered the most contrary types of national research and innovation systems, show that relations between the private and the public sectors are anything but straightforward. Institutional support goes far beyond financial support and relates to the creation of an ecosystem conducive to technological development.

**Box 4. King Abdulaziz City of Science and Technology**

The King Abdulaziz City of Science and Technology (KACST) is host to both the Saudi Arabian national science agency and its national laboratories. The science agency function involves science and technology policy-making, data collection, funding of external research, and services such as the patent office. KACST is a genuine "science city" with three components: research, innovation and services for the public and private sectors. It has 15 research teams in different disciplines and three programmes on industrial property, an incubator and innovation centres, plus a grant system "to encourage excellence and innovation". In 2011, KACST had a budget of almost US$0.5 billion, offering grants to 64 researchers and research teams. It is interesting that only 23 per cent of KACST's budget is invested in basic science, while the remainder is distributed among the applied sciences (31 per cent in medicine, 27 per cent in engineering and 16 per cent in agriculture) (KACST, 2012, p. 105).

[88] Arvanitis and M'henni, 2010.

**Box 4** (*continued*)

KACST currently has over 2,500 employees. Its main responsibilities can be summarized as follows:

1. Propose a national policy for the development of science and technology and develop strategies and plans necessary to implement them.
2. Coordinate with government agencies, scientific institutions and research centers in the Kingdom to enhance research and to exchange information and expertise.
3. Conduct applied research and provide advice to the government on science and technology matters.
4. Support scientific research and technology development.
5. Foster national innovation and technology transfer between research institutes and the industry.
6. Foster international cooperation in science and technology.

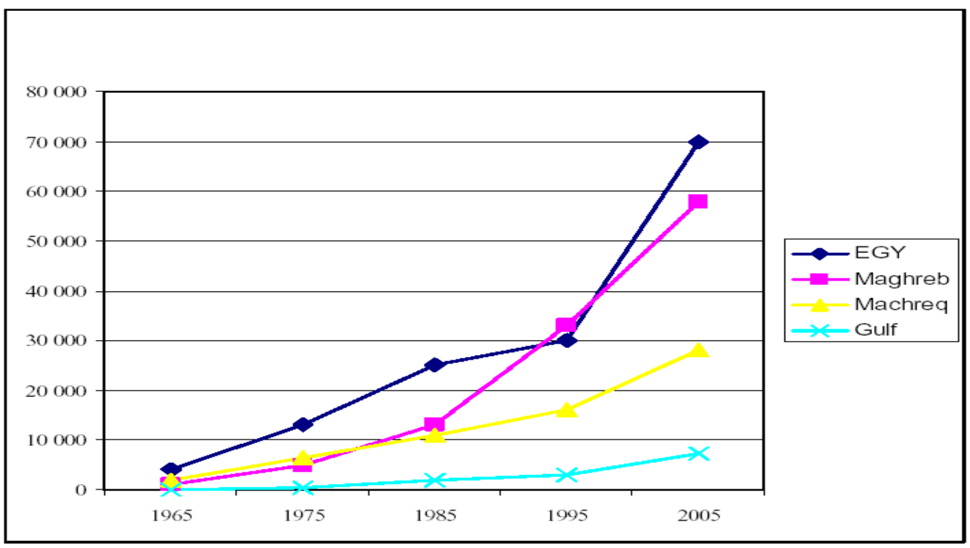
## IX. SCIENTIFIC CAPITAL: UNIVERSITIES AND RESEARCHERS

Knowledge production cannot be understood without investigating the researchers themselves. Algeria, Egypt and Morocco are now on the path to mass higher education; hence they possess a larger reservoir of teachers doing research. Some countries lacking a proper university system are also on the ascendant, including Libya, Syria and Iraq (which in fact had a famous educational system before war ravaged the country). The rest have developed a national system with universal access, but limited capacity. In addition, in all these countries a new massive actor has appeared: private universities that absorb the elite and the upper-middle classes. The existence of good universities is thus part of the story of research, but hardly the only one. A research system needs talented persons but also viable management that helps ground research inside the university and gives it the ability to address national solicitations, propose novel courses or methods, and fill the gaps of unnoticed, promising niches.[89]

Table 1 summarizes some of the indicators available concerning human resource potential. Preparing researchers begins with investing in their higher education. This is shown with state education budgets ranging from 0.8 per cent of the GDP for Egypt and Algeria to 1.2 per cent of GDP in Tunisia. However, actual investment is larger, as budget allocations do not include private and not-for-profit universities. In fact, only a few private institutions play a significant role in research, notably the American University of Beirut (AUB) and St Joseph (USJ) in Lebanon, and the Université des Sciences et de la Technologie Houari Boumediène (USTHB) in Algeria.

All higher education institutions produce a huge number of students: approximately 1.8 million in Egypt, including 102,000 graduate students; and 750,000 in Saudi Arabia, including 11,000 graduate students.[90] Figure 13 shows the development of the number of faculty in Arab universities, which has been steadily increasing since 1965. Note, however, that figures in Egypt and the Gulf began to increase only in 1995.

**Figure 13. Growth of academics in Arab countries (1965-2005)**




*Source*: Mouton and Waast, 2009.

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[89] Mouton and Waast, 2009.

[90] The number of students in the Arab region has increased considerably, from 5.4 million in 2000 to 7.3 million in 2008. In 2000, there were 1,907 students for 100,000 inhabitants. By 2008, this number had increased to 2,185 UNESCO, 2010, p. 68.

It is very difficult to draw a direct correlation between the number of graduates or faculty and the number of researchers, as many students and faculty members do not go into research. Only a small percentage would possess visible knowledge in the international arena, through publications in refereed journals counted by the Web of Science or Scopus. The reason is not only related to language but also the fact that many Arab universities are not research universities, even if their bylaws state otherwise. From 33,481 researchers in Egypt, statistics suggest that 13,941 are on full-time equivalents (FTE), but indeed only half of them will publish in refereed journals. The FET in Egypt is certainly exaggerated, as we know it is rare for the actual research activity of teaching staff in government and most private universities to exceed 5 to 10 per cent of their total academic duties, whereas it forms 35-50 per cent of academic duties in European and American universities.[91] In a university like AUB, where research is a frequent activity, our survey shows that around 40 per cent of academics' time is spent on research. This is an average of two publications per year for each FTE at AUB (table 2; for comparison, see other universities in Lebanon. Note the difference with the Lebanese University, a public institution).

TABLE 11 (A). DISTRIBUTION OF COUNTRIES ACCORDING TO GDP PER CAPITA AND NO. OF RESEARCHERS PER MILLION INHABITANTS

| | Expenditures in higher education | | | | Number of universities (2006) | Students | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country | In million US$ | Percentage of GDP (2008) | Percentage of government budget (2007) | per student (2007) | | Number of students (2007) | MSc students (2006) in science and technology | MA students (2006) in social sciences and humanities | PhD students (2006) in science And technology | PhD students (2006) in social sciences and humanities |
| Egypt | 1 300 | 0.8 | | $757 | 31 | 1 776 699 | 50 287 | 28 445 | 14 609 | 9 202 |
| Iraq | | | | | | | | | | |
| Syria | 454 | 1.04 | 3.57 | $814 | | 558 131 | | | | |
| Libya | | | | | 13 | | | | | |
| Algeria | 636 | 0.8 | | | 26 | | 15 308 | 9 873 | 7 689 | 4 917 |
| Mauritania | | | | | 1 | | | | | |
| Morocco | 777 | 0.92 | 3.8 | $2 748 | 15 | 282 724 | 6 117 | 6 500 | 6 702 | 4 147 |
| Tunisia | 681.80 | 2.04 | 6.45 | $1 948 | 35 | 350 000 | 6 854 | 11 730 | | |
| Bahrain | | | | | 16 | | 83 | 468 | 1 | 0 |
| Kuwait | | | | | 9 | | | | | |
| Oman | | | | | 4 | | 263 | 302 | 1 | 0 |
| Qatar | | | | | 7 | | | | | |
| Saudi Arabia | 6 100 | 1.30 | 1.90 | $8 186 | 17 | 670 341 | 3 403 | 5 733 | 338 | 1 862 |
| UAE | | | | | 33 | 30 200 | | | | |
| Sudan | | | | | | | | | | |
| Yemen | | | | | 21 | | 496 | 1 494 | | |
| Jordan | | | | $763 | 26 | 200 000 | 779 | 799 | 30 | 6 |
| Lebanon | $118 | 0.5 | | $1 635 | 41 | 147 600 | | | | |

[91] UNDP, 2009, p. 190.

TABLE 11 (B)

| Country | Researchers | | | | |
|---|---|---|---|---|---|
| | number of researchers (2005) | Researchers per 1 million inhabitants (2007) | Estimates on full-time equivalents (FTE) (2008) | FTE per million population (2007) | Number of scientists and engineers in refereed journals (2010) |
| Egypt | 33 481 | 420 | **13 941** | 617 | **7 669** |
| Iraq | | | | | 499 |
| Syria | | | | | 75 |
| Libya | 390 | 61 | | | 24 |
| Algeria | 5 764 | 170 | 5 944 | 170 | 2 283 |
| Mauritania | | | **411** | | **19** |
| Morocco | 17 516 | 166 | 4 699 | 647 | 1 877 |
| Tunisia | 25 445 | **492** | 5 625 | 1 588 | 4 041 |
| Bahrain | **1 000** | 1759.33 | | | 222 |
| Kuwait | 158 | 152 | 634 | **166** | 894 |
| Oman | 1 200 | 613.08 | 548 | 19.71 | 698 |
| Qatar | 10.5 | 42 | 789 | 464.12 | 567 |
| Saudi Arabia | 716.07 | **41** | | | 5 176 |
| UAE | 3 500 | 3314.5 | 875 | 116.66 | 1 717 |
| Sudan | 12 615 | 290 | | | |
| Yemen | | | 486 | | |
| Jordan | **42 151** | 280 | 2 223 | **1 952** | |
| Lebanon | 13 316 | 200 | 565 | 178 | |

A recent study that relies primarily on government data from ten Arab countries ('Abd al-Majid Salih, 2008) shows women accounted for 40 per cent of researchers in Egypt and Kuwait, 30 per cent in Algeria and Qatar, and 20 per cent in Morocco and Jordan. Their numbers fell to between 14 and 4 per cent in Oman, Yemen and Mauritania.[92]

Beyond the numbers, where are these researchers located? While in social sciences they are located in NGO-status research centres and universities, in other sciences they are mainly located in universities and public research centres[93] (or state-sponsored science parks). Research has shown that the bulk of S&T research in the Arab region is carried out within the higher education system, even in Egypt, where this represents 65 per cent of R&D.[94] In 2008 Arab countries spent $16.26 Billion on higher education for 6.62 million students.[95]

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92 (UNDP, 2009, p. 191), 30 per cent of 125,000 university faculty members in Arab countries are women. Some researchers have put this figure at over 170,000 (Waast et al., 2010), but this could be due to the inclusion of individuals who teach at more than one university, meaning they would be counted more than once (UNESCO, 2010, p. 71).

93 These centres are generally specialized in specific spheres of public interest (agriculture, nuclear and space technologies, health) with a continuum from basic to applied research. They are often favored by Governments, which give priority to their funding because they contribute to areas of national strategic importance and are commissioned to generate more practical outcomes. (IFI, 2011).

94 IDSC, 2007, UNESCO, 2010, p. 257.

95 Mrad, 2011.

## A. SCIENTISTS OR A SCIENTIFIC COMMUNITY?

An issue raised by many researchers[96] is the dispersion and lack of ‘critical mass’ in specific niches. The concentration of knowledge production in most countries has been well documented: a small number of establishments and scientists produce the bulk of results in most science systems. A more refined analysis (per establishment and per field and topic) may, however, give a better result: it has been well documented in countries like Morocco and Jordan that even in leading establishments, there are no more than 20 successful research niches; and within each of these no more than ten very active researchers and 20 more episodic contributors.[97] These persons very often do not collaborate with people beyond their own institution (except for international collaborators), and the quality of national research remains fragile. There may thus be problems regarding the reproduction, updating and renewal of research methods, capabilities and subjects.

Usually when we refer to the notion of ‘critical mass’ to explain that after a certain quantity of personnel and resources some successful process is triggered that might favour research. The idea has been clearly argued by De Solla Price explaining how the creation of a scientific research community responds to a growth process leading to “big science” in particular in fields established following the Second World War, such as nuclear and high-energy physics. However, no one has yet proven the ‘right’ critical mass for triggering the construction of a scientific community. The concept has in fact no empirical basis, and the statistical calculation offered by De Solal Price was limited to a period of exceptional growth within the research community. Of course, numbers count, and having 60 researchers in an area is certainly better than having only one or two, although research can be the result of collaboration and these could very well be maintained by ‘low-level’ activity.

TABLE 12. LEBANON’S RESEARCH PERFORMERS – BY DECREASING ORDER OF SCIENTIFIC PUBLICATIONS

| University | Publications 2000-2003[a] | R&D personnel FTE[b] | Expenditures on R&D[b] | Total teaching Staff[c] | Total students[c] | Year of foundation |
|---|---|---|---|---|---|---|
| American University of Beirut (AUB) | 607 | 100 | 17,8 | 813 | 7 000 | 1 866 |
| Lebanese University (UL) | 162 | 150 | 11,4 | 4 400 | 71 000 | 1 953 |
| Saint Joseph University (USJ) | 160 | 90 | 8,0 | 1 830 | 9 800 | 1 875 |
| Beirut University Hospital | 63 | ? | | | | |
| Lebanese American University (LAU) | 42 | 10 | | 180 | 4 500 | 1 924 |
| Balamand University (BU) | 22 | 20 | | 940 | 2 800 | 1 988 |
| Beirut Arab University (BAU) | 15 | 10 | | 670 | 13 500 | 1 960 |
| 34 other universities | 26 | 40 | Together: 6,0 | 4 900 | 39 000 | 3 out of 4 since 1996 |
| CNRS: 4 Research Centres | 15 | 50 | 5,5 | | | |
| LARI (Agric Res) | | 55 | 5,2 | | | |
| IRI (Indus Res) | | 10 | 0,3 | | | |
| 5 Other Res. Centres | Together: 10 | 30 | | | | |

*Notes*: Table and estimates performed by Jacques Gaillard, 2007.

a/ Figures from PASCAL database, elaborated by Rossi, IRD.

b/ Input estimates in personnel and funding based on in-depth interviews and data collection performed in Lebanon in 2007.

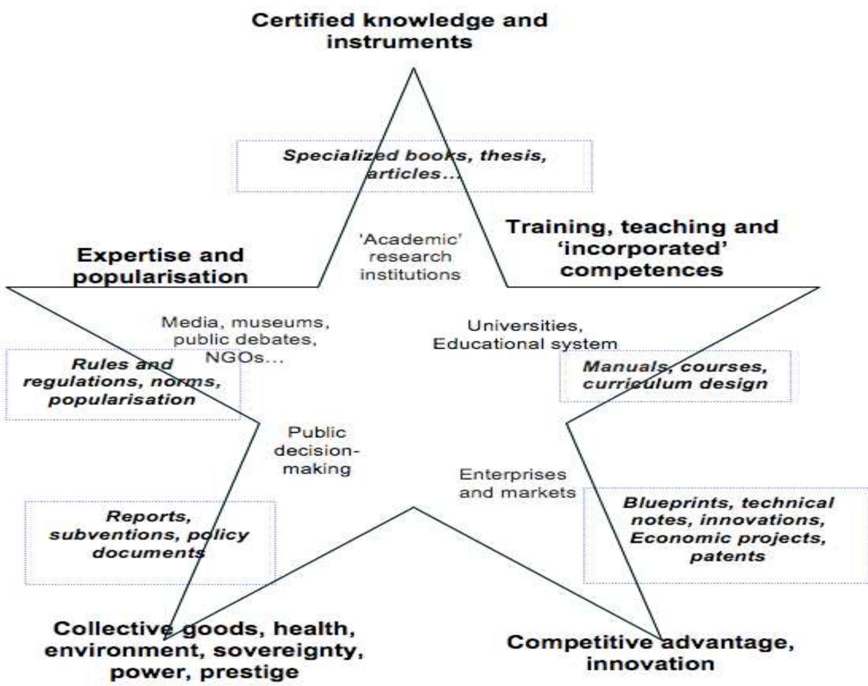
c/ Collection of data from universities and Ministry of Education and Higher Education, 2007.

96 Mouton and Waast, 2009.

97 Kleiche and Waast, 2008.

Some aspects that seem important are the structuring of the scientific community,[98] which in turn favours the creation of strong research teams (an institutionalization process that can be accelerated only to the extent that research teams are consolidated).[99] What seems to be decisive is not so much the number of researchers but rather the connections of the research activity with non-research activities, be they economic or otherwise; R. Waast has called this a 'pact' between scientists and society.[100] It is necessary here to understand that researchers have multiple functions. They produce academic work, visible through their production in scientific journals; but they also have other functions. Figure 14 (The 'Rose of Winds' of Research) indicates schematically most of these functions: they range from the production of codified and approved knowledge by the scientific community to other functions such as advocacy, public knowledge, training and teaching, contributions to patenting and enterprises, expertise and popularization. Again, we must stress the extreme diversity of types of scientific research, making it difficult to have a one-size-fits-all scheme of support for research.

**Figure 14. The 'Rose of Winds' of research**




*Source*: Callon, M., Larédo, P. and Mustar, P. (Eds.), 1997. The strategic management of research and technology. The evaluation of research programmes. Paris: Economica.

## B. International cooperation

In all fields of research, collaboration is crucial in research projects; it helps researchers pool ideas together and move forward at a faster pace. Equally, it provides some researchers with an insight into other fields of relevance.

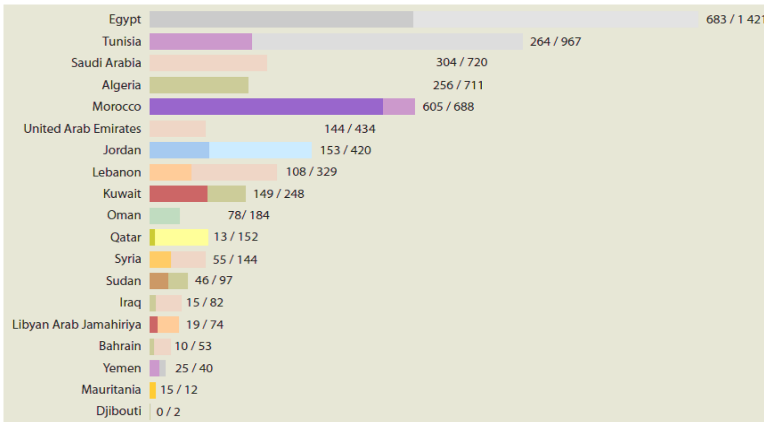
[98] Gaillard, Krishna and Waast, 1997.

[99] Vessuri, 2004.

[100] Waast, 2006.

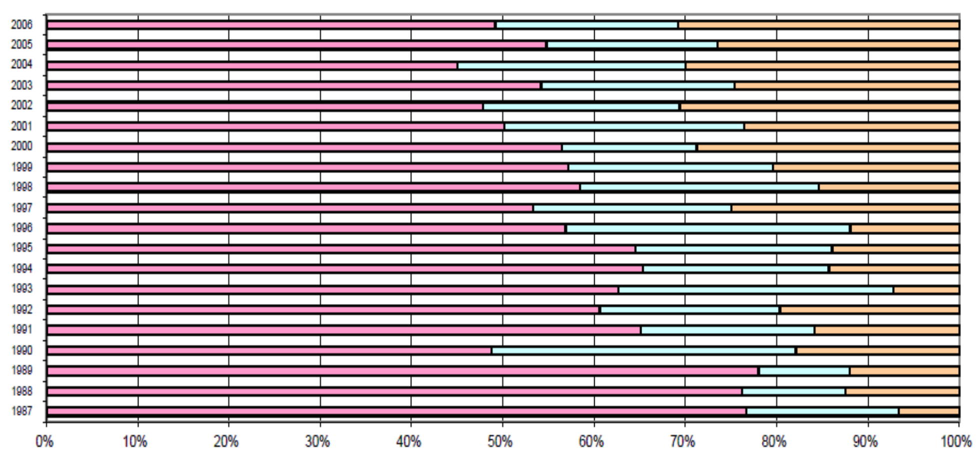
In their paper, “Where is Science going?” Diana Hicks and Sylvan Katz note that “International collaboration is often singled out for special mention. It has been a concern of recent European Union science policies and of bibliometric analysis”. They find that “the increased cost of certain instruments, the increased scope of many problems, the global reach of research- intensive multinational companies, and increased travel and communication are combining to make the scientific community even more transnational – research having always been a more international pursuit than most”.[101] These drivers for international collaboration have been confirmed by a recent review of topics on the theme, prepared as a background document for the European Commission.[102]

**Figure 15. Scientific Co-publications in the Arab region (2000-2008)**




*Sources*: UNESCO, 2010, p. 267.

**Figure 16. Publications and co-authorship: Lebanon 1987-2008**




| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| With EU | 6 | 10 | 6 | 7 | 10 | 13 | 6 | 14 | 13 | 13 | 45 | 30 | 50 | 76 | 71 | 91 | 85 | 112 | 120 | 131 |
| Without EU | 15 | 9 | 5 | 13 | 12 | 13 | 25 | 20 | 20 | 34 | 39 | 51 | 55 | 39 | 79 | 64 | 73 | 93 | 85 | 85 |
| Lebanon only | 69 | 61 | 39 | 19 | 41 | 40 | 52 | 64 | 60 | 62 | 96 | 114 | 140 | 149 | 151 | 142 | 187 | 168 | 248 | 209 |

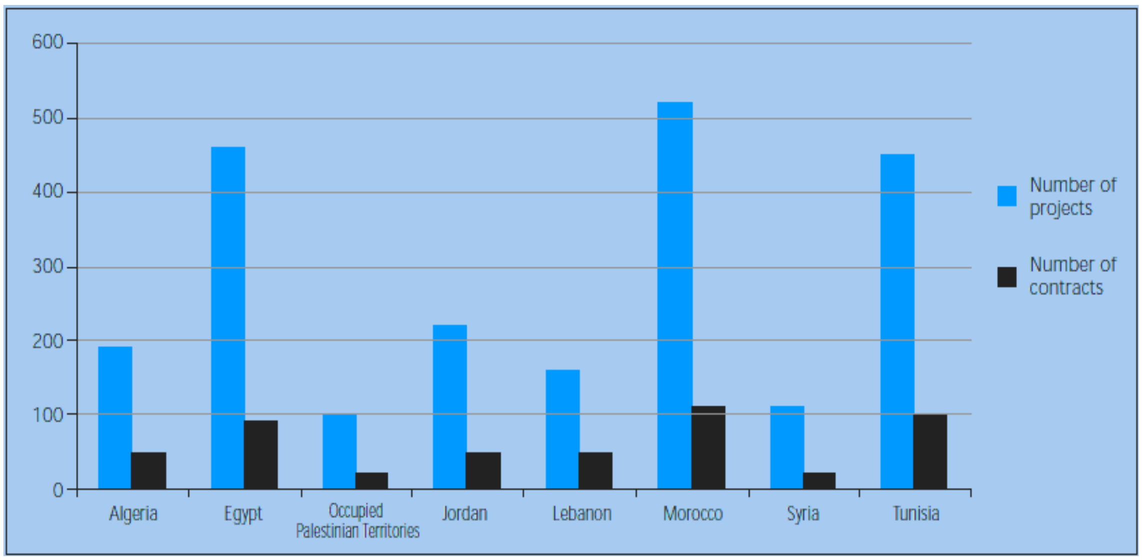
Thomson scientific data, P.L. Rossi/IRD computing

101 Hicks and Katz, 1996, p. 394.

102 Boekholtetalii, 2009.

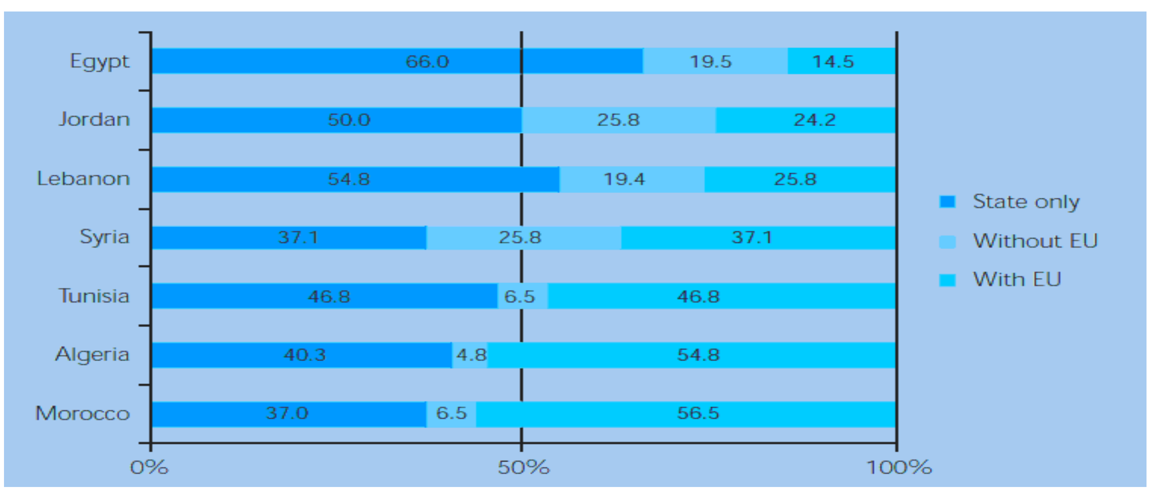
Bibliometric studies carried out in recent years are all unanimous in finding that there has been a sharp increase in scientific collaborations, and more specifically in international collaborations. Increasingly, Arab scholarship is done in cooperation with scholars abroad, as we see in figure 17, indicating the difference between 2000 and 2008. The case of Lebanon is interesting because not only do we see more international co-authorship (figure 19: co-publication increased from 22 per cent in 1987 to 55 per cent in 2006), but also progressively progressive re-orientation toward more collaborations with European partners. We notice that the European Union, and in particular France, is the major region of cooperation, thanks to its funding system (figure 20).

**Figure 17. Arab Participation in the European Union's Sixth Framework Program (2002-2006)**




*Sources*: UNDP and Al Maktoum Foundation, 2009, p. 193.

**Figure 18. Arab-International cooperation in scientific dissemination (2004)**




*Source*: UNDP and Al Maktoum Foundation, 2009.

We see that the United States is an important partner for Egypt, Jordan, and Lebanon, particularly AUB and the Lebanese American University. France has been a privileged partner for Morocco, Algeria and to a lesser extent Tunisia. In general, France is the main scientific funder for international projects in the Mediterranean region, through bilateral programmes.[103]

Also, co-authorship with the European Union has grown in all countries (even those usually 'preferring' the United States), and this is directly due to the effort put by the European Union to open its programmes systematically to non-European Union partners (Arvanitis, 2012).

TABLE 13. ARAB-INTERNATIONAL COOPERATION IN SCIENTIFIC PUBLISHING

| | Tunisia | | Egypt | | Lebanon | |
|---|---|---|---|---|---|---|
| Rank | Country | Percentage | Country | Percentage | Country | Percentage |
| 1. | France | 77.0 | United States | 27.9 | France | 37.0 |
| 2. | United States | 5.7 | Germany | 14.9 | United States | 32.3 |
| 3. | Germany | 4.1 | Saudi Arabia | 12.4 | United Kingdom | 10.1 |
| 4. | Italy | 3.7 | Japan | 10.3 | Canada | 6.9 |
| 5. | Belgium | 3.6 | United Kingdom | 8.6 | Bahrain | 4.5 |
| 6. | Canada | 3.6 | Canada | 5.3 | Italy | 3.8 |
| 7. | United Kingdom | 3.1 | Italy | 4.1 | Saudi Arabia | 3.2 |
| 8. | Morocco | 2.2 | Belgium | 3.1 | Germany | -- |
| 9. | Spain | 2.1 | France | 2.9 | Australia | -- |
| 10. | Algeria | 1.5 | Spain | 2.2 | Egypt | -- |

*Sources*: UNDP and Al Maktoum Foundation, 2009, p. 199.

Finally, it is important to note that the hierarchy of countries with which partnerships are engaged in, is very sensible to policy. It is also changing rapidly in the last decade. The appearance of Saudi Arabia, Italy and Spain as frequent co-authors is remarkable. It relates to a proactive policy of international cooperation on the part of the authorities of these countries as much as to the growth of research activity. Spain, for example, has seen a massive growth in its international collaborations, in particular (and understandably) with Latin America. It has also seen more cooperation with Morocco and other Maghreb countries. Italy has also had a very sharp increase in its participation in international programmes with neighbouring countries in areas of its competence (cultural heritage, archaeology, agricultural sciences, food sciences). The more 'traditional' players (France and the United States) have seen their relative share diminish, but nevertheless saw growth in the context of increasing collaborations and co-authored publications.

## C. INTER-ARAB COOPERATION

Our investigation of research practices at AUB, the Lebanese University and USJ shows how limited Arab inter-regional cooperation is.[104] This concurs with the work of Antoine Zahlan, who points out that there have been some 1,000 research papers published on aquifers by scientists, though few scientists collaborate to enable them to bring their expertise to serve the entire region.[105] Collaboration is weak even within the same country. Our survey in Lebanon among AUB faculty found that interviewees at AUB collaborate both with other faculty members at AUB and with other researchers abroad, notably through contacts formed during PhD and postdoctoral years. However, very few had ever collaborated with researchers in Lebanon not affiliated with AUB. A professor in the faculty of medicine mentioned that "scientists in the Arab region do not communicate with one another- they tend to remain in the same field,

[103] Arvanitis, 2012.

[104] Hanafi, Arvanitis and Baer (2013).

[105] Zahlan, 2012, p. 193.

whereas scientists abroad communicate and evolve in their research". This is a quite common, but partly faulty, perception. In fact, the survey done on international collaborations by the MIRA project tends to show that the behaviour of Arab scientists is not very different from that of their European, Turkish or Israeli counterparts. The main difference between Arab researchers and Europeans is instead a lack of time to do research.[106] In the Gulf area, we notice a recent increase in co-publications within the Gulf region. As we see in table 4, the United Arab Emirates and Saudi Arabia have the most co-publications, although these figures vary (23 and 19 publications respectively).

TABLE 14. CO-PUBLICATION BETWEEN THE GULF COUNTRIES (2005)

| Country | Bahrain | Kuwait | Oman | Qatar | Saudi Arabia | UAE | GCC | Total |
|---|---|---|---|---|---|---|---|---|
| Bahrain | 0 | 0 | 1 | 0 | 4 | 3 | 2 | 10 |
| Kuwait | 0 | 0 | 3 | 0 | 4 | 5 | 3 | 15 |
| Oman | 1 | 3 | 0 | 1 | 3 | 4 | 1 | 13 |
| Qatar | 0 | 0 | 1 | 0 | 1 | 4 | 2 | 8 |
| Saudi Arabia | 4 | 4 | 3 | 1 | 0 | 5 | 2 | 19 |
| UAE | 3 | 5 | 4 | 4 | 5 | 0 | 2 | 23 |
| GCC | 2 | 3 | 1 | 2 | 2 | 2 | 0 | 12 |
| Total | 10 | 15 | 13 | 8 | 19 | 23 | 12 | 88 |

*Source*: Scopus cited by Zahlan, 2012, p. 162.

[106] Gaillard et al. forthcoming.

# X. BRAIN DRAIN AND SCIENTIFIC DIASPORAS

Currently, brain drain is a major concern in the Arab region. Figures released by the Organisation for Economic Co-operation and Development (OECD) show that around one million highly qualified persons of Arab origin reside in the OECD countries. This number corresponds to 10 per cent of the highly qualified population in the Arab region, and 20 per cent of the corresponding population for the Maghreb countries.[107] In table 5, we see the number of Arab expatriates and percentage of highly skilled expatriates by country of birth.

TABLE 15. TOTAL NUMBER OF ARAB EXPATRIATES AND PERCENTAGE OF HIGHLY SKILLED EXPATRIATES BY COUNTRY OF BIRTH

| Country | Total number of expatriates | *of which:* highly skilled (*Percentage*) |
|---|---|---|
| Algeria | 1 301,076 | 16.4 |
| Bahrain | 7,424 | 40.6 |
| Egypt | 274,833 | 51.2 |
| Iraq | 294,967 | 28.2 |
| Jordan | 575,992 | 48.9 |
| Kuwait | 37,591 | 44.1 |
| Lebanon | 332,270 | 32.9 |
| Libya | 27,481 | 43.4 |
| Mauritania | 14 813 | 18.5 |
| Morocco | 1 364 754 | 14.8 |
| Palestine | 14 798 | 43.8 |
| Oman | 2 753 | 36.9 |
| Qatar | 3 384 | 43.3 |
| Saudi Arabia | 34 646 | 35.4 |
| Sudan | 42 086 | 40.5 |
| Syria | 126 372 | 34.1 |
| Tunisia | 371 274 | 17.7 |
| UAE | 14 589 | 23.9 |
| Yemen | 32 428 | 19.3 |

Mouton and Waast give us more details from the United States as the National Science Foundation in 2000 revealed that there are thousands of Arab scientists and engineers living in the United States: 12,500 Egyptians, 11,500 Lebanese, 5,000 Syrians, 4,000 Jordanians and 2,500 Palestinians.[108] Scientists from Morocco and Tunisia tend to head for Europe.[109] As can be seen in table 16, the total number of researchers in Lebanon is only slightly larger than the number of Lebanese researchers employed in R&D in the United States. This shows the importance of the phenomenon of brain drain.

The Arab region is considered one of the most active in terms of the export of highly qualified human capital equipped with university degrees. Indeed, human capital is among the region's major exports, possibly equal to oil and gas in value. What little data is available sustains this claim: 45 per cent of Arab students who study abroad do not return to their home countries; 34 per cent of skilled doctors in Britain are

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[107] Wahishi, 2010, p. 7. As a rule, it appears than immigrants are "more qualified" than the native-born population: In the OECD area as a whole, the share of people with tertiary education is higher for the foreign-born (23.6 per cent) than for the native-born (19.1 per cent) (Dumont and Lemaître, 2005). It should be remembered that immigrants populations have played a fundamental role in the economic and technological growth of many industrialized countries, in Europe, North America etc (Rosenberg, 1982; Inkster, 1991).

[108] Mouton and Waast, 2009.

[109] Waast et al., 2010; UNESCO, 2010b, p. 271.

Arab; and the Arab region has contributed 31 per cent of the skilled migration from developing states to the West, including 50 per cent of doctors, 23 per cent of engineers, and 15 per cent of scientists.[110] Over 200,000 PhD holders (80 per cent of all Arab doctorate holders), unable to connect with the local economy, emigrate (Mrad, 2011). An IRD expert report on "scientific diasporas" reported on this topic in 2003, including an exceptional study by Jean Johnson, from which we extracted some indicators reproduced in table 16, alongside data from the ESTIME project. There is a need to better understand the reasons for the scientific diaspora in relation to general emigration from the Arab region.

The situation is very different in the Maghreb and the rest of the Arab region. According to the National Science Foundation, very few scientists from the Maghreb are established in the United States; rather, scientists from the Maghreb head to Europe (mainly France), and more recently to Canada. A bibliometric study in the social sciences has recently proven that 60 per cent of the most productive social scientists from Algeria are now living and employed abroad (50 per cent of the 200 most productive, authoring more than 1/3 of Algeria's scientific production over the last 25 years). The proportion of Moroccan authors living abroad is much lower, at 15 per cent of the most productive.[111] According to the Algerian trade unions, the number of Algerian scientists established abroad had increased from 2,400 in 1984 to 27,500 in 1994; in 1995, 90 per cent of scholarship holders had never returned from abroad. To this should be added the well-known exodus of "highly qualified persons" (including a number of leading researchers and academics) during the civil war of the 1990s.[112] However, Hocine Labdelaoui argues that because of many "push" factors in France and an improvement of the situation in Algeria, many Algerian faculty and researchers have been convinced to return to their country.[113]

There is a range of opinions on brain drain. In many countries, the official point of view is that these emigrants are despicable traitors, who prefer their own material well-being to the interests of their homeland. Added to that is the claim that there is a deliberate "pirating of brains" by the wealthiest countries, at the expense of the poor countries which bore the costs of their education.[114]

TABLE 16. BRAIN DRAIN FROM THE MIDDLE EAST: NUMBER OF SCIENTISTS AND ENGINEERS ESTABLISHED IN THE UNITED STATES, 2000

| | Egypt | Lebanon | Jordan | Syria | Palestine | Kuwait | Maghreb |
|---|---|---|---|---|---|---|---|
| Established in the United States | 12 500 | 11 500 | 4 000 | 5 000 | 2 000 | 2 400 | Few |
| Employed in R&D | 4 400 | 4 900 | 2 000 | 1 800 | 700 | 1 200 | Few |
| Researchers in the country* | 75 000 | 6 000 | 6 500 | n.a. | n.a. | 2 400 | 40 000 |
| Researchers in the country (FTE)* | 15 000 | 600 | 750 | 400 | n.a. | 500 | 8 000 |

*Sources*: Johnson, J. (NSF) in Barré et al., 2003.

* ESTIME www.estime.ird.fr.

There are elements of truth in these arguments; but researchers are not the only ones fleeing these countries, and there is no reason for them to remain hostages of Governments that do not care (or know how) to use their talents. Moreover, this argument seems to indicate the idea that highly-skilled individuals, because of their training, are somehow the property of their State. The view draws back to the concept of state-driven development, which was predominant in the post-Second World War era.[115] Some recent

[110] Zahlan, 2004; UNDP, 2009, p. 208.

[111] Waast and Rossi, 2009.

[112] Khelfaoui, 2004.

[113] Lablaoui, 2010.

[114] Mouton and Waast, 2009.

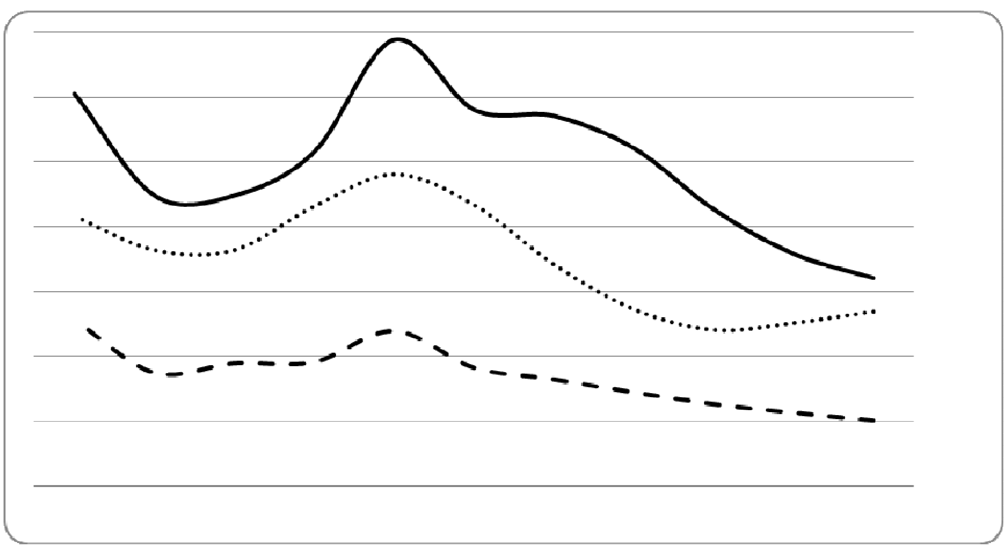
[115] Gaillard, Krishna and Waast, 1997; Amsden, 2001.

studies have convincingly proven that most researchers' attitudes depend on national science policies, and on the movements of international industry. The North African case has been well-documented: if the profession is decently treated (status, income), scientific life can go on, and brain drain is much lower. In these cases, students return home upon the completion of degrees abroad. They may give up lucrative careers in the emigration countries, preferring (managerial) positions in their home environment.[116]

Another feature is noteworthy: since the decision of some multinational firms to invest in Morocco three years ago (in high-tech production, and even in development research), the country has had to hastily develop a training plan to double the number of graduate engineers; it has been only partially able to meet this objective. Part of Morocco's appeal to these firms is the quality of its 'elite' engineering schools (modeled on the example of French 'Grandes Ecoles'; the same holds true of Tunisia. The lowered cost of managerial salaries in these Maghreb countries combined with the quality of the engineering training make these countries attractive to subsidiaries of multinational firms.

Another opinion is that there is no real brain drain, but rather a natural flow of scientists to the best places in which to exercise their talents. The "marketplace of knowledge" will determine their settlement to the best effect, each place in the world will have what it "deserves", and the task of governments is to offer the best conditions to retain the best researchers. This view is becoming predominant and is attached to the multi-polar world system that has been emerging since the late 1980's, with the State's loss of control over their own training-to-employment system. It should be emphasized that some countries had very restrictive systems of scholarships for their most talented young student, which permitted them to be trained abroad in exchange for a promise of employment, usually in the public sector, upon their return. Such has been the case for example in the Syrian Arab Republic, and returnees that 'escaped' their return obligation had to pay fines or, worse, had to confront menacing security services. Thus international mobility is not a given, even for the highly skilled. Dumont and Lemaître argue that the largest developing countries seem not to be significantly affected by brain drain, and indeed may benefit from the indirect effects of mobility; meanwhile, some of the smallest countries, especially in the Caribbean and in Africa, face the emigration of large portions of their elite.[117]

**Figure 19. Number of Moroccans, Algerians and Tunisians in French Universities**



*Source*: French Ministry of Higher Education. Cited by Latrache, 2010. Legend: ___Moroccan, …Algerian, - - - Tunisian.

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[116] Gérard et al., 2008.

[117] Dumont and Lemaître, 2005.

To overcome brain drain, the work conditions for researchers should be improved (through provision of an environment conducive to research and the increase of their salaries). In Africa many studies show how brain drain has been, if not reversed, at least slowed down by simply providing better conditions. Here we would like to provide three options for such a reversal: top-down initiatives for higher education, temporary recruitment of expatriate experts, and networking with the diaspora.

### A. TOP-DOWN INITIATIVES IN HIGHER EDUCATION

Three regional initiatives exemplify recent top-down initiatives in higher education: Qatar's Education City (box 5); the Masdar Institute in Abu Dhabi, and the King Abdullah University of Sciences and Technology in Saudi Arabia. These initiatives are likely to staunch brain drain in Arab countries, which have been hit by an exodus of talent.[118]

**Box 5. Qatar's Education City: An example in "branding" strategy**

A branding strategy consists of inviting a famous foreign university or institution to create a local branch and use its name in the country. The Qatar Foundation has funded the Qatar Education City, which includes branches of eight elite international universities, delivering "world-class programs chosen to ensure Qatar is equipped with essential skills and specialties". The schools are: Texas A&M University at Qatar, Weill Cornell Medical College in Qatar, Georgetown University School of Foreign Service, Virginia Commonwealth University in Qatar, Carnegie Mellon University, Northwestern University in Qatar, Ecole des Hautes Etudes Commerciales (HEC Paris), and University College London Qatar. The city is also home to educational institutions for children and teenagers, and research institutions such as the RAND-Qatar Policy Institute, the Qatar Science & Technology Park, and the Qatar National Research Fund. The Qatar Education City is also the home to the Qatar Music Academy and Qatar Symphony Orchestra.

Some Gulf countries are now offering excellent facilities to international enterprises and universities, in order to attract and territorialize them. For instance, the University of King Abdel Aziz attracted 20 scientists from the UK in 2012 by providing each one US$1 million for their research. So far, however, it has not found niches of excellence. This top-down initiative can originate with the State or private institutions. In the latter, one can highlight the effort of the American University of Beirut and other universities in Lebanon in attempting to reverse the brain drain of medical doctors. Based on a 2009 survey conducted among Lebanese doctors practicing in the United States,[119] 61 per cent of the 286 participants were willing to relocate to Lebanon, but only a third were willing to relocate to the Arab Gulf. Slightly more than half were willing to relocate to Lebanon as a base for clinical missions to the Gulf. These findings suggest that there is a possibility to make Lebanon a regional 'academic hub' by recruiting Lebanese medical graduates practicing abroad.[120] It is also worth mentioning that Berytech, was initially conceived as a way to repatriate young professionals that were fleeing the country.

### B. "BRAIN GAIN": TEMPORARY RECRUITMENT OF EXPATRIATE EXPERTS

While connectivity between the diaspora and the homeland is an important factor in fostering physical return, a temporary physical return remains possible for skilled expatriates, a category whose participation is vital to the construction of the Arab region, especially following the popular upheavals of recent years. In this case, it is possible for Arab Governments or the international community to harness this group and facilitate the transmission of their expertise for the benefit of their homelands. As Meyer et al. argue, there are two possible policies for developing countries to tap their expatriate professional communities, either through a policy of repatriation (a return option), or a policy of remote mobilization and connection to

[118] UNESCO, 2010b, p. 71.

[119] Of a sample of 500 physicians contacted by researchers, 286 participated in the survey.

[120] Akl et al., 2012.

scientific, technological and cultural programmes at home (a diaspora option).[121] Let us present the Palestinian case to see what lessons can be learned for the Arab region.

These two policies have both been employed in Palestine: in the former through a UNDP programme which encourages repatriation, called TOKTEN (Transfer of Knowledge Through Expatriate Nationals),[122] and in the latter through an internet-based network called PALESTA (Palestinian Scientists and Technologists Abroad).

The TOKTEN concept is an interesting mechanism for tapping expatriate human resources and mobilizing them to undertake short-term consultancies in their countries of origin. The UNDP, which implemented TOKTEN in order to utilize the expertise of expatriates, demonstrated that emigrants who had achieved professional success aboard were enthusiastic about providing short-term technical assistance to their country of origin. Indeed, many of these individuals returned and settled permanently in their home country. This programme has been applied over the past 22 years in 30 different countries, resulting in the application of thousands of technical assistance missions by expatriate professionals to their countries of origin.[123] One of the main catalysts for the creation of the TOKTEN programme was the growing necessity of counteracting brain drain from developing countries to the first world. Over the course of the 1990's, the programme created databases of expatriate experts and gave assignments to more than 400 of them per annum to volunteer projects[124] to their countries of origin for periods ranging from one to six months. TOKTEN volunteers have served in government, the private sector, academic institutions and NGOs.

One of the most successful TOKTEN programmes is in Palestine, with over 170 Palestinian experts having contributed their time and expertise. Palestinian TOKTEN consultants have helped reform the treatment of kidney disease in Palestine and have guided the development of macro-economic frameworks and planning. TOKTEN skills have also been brought to bear in the realm of computer and information technology, on city planning, on university curriculum development and academic networking, on the upgrading of film and television capacities, and on cultural preservation, including the Bethlehem 2000 project. TOKTEN has generated some genuine success stories in Palestine, such as the construction and opening of the international airport in Gaza. In this case, nine TOKTEN consultants have stayed on and presently constitute the backbone of the airport's operations.[125]

The TOKTEN experience also provided returnee experts with a first-hand taste of life in their homeland and encouraged them to settle (within the limits of Israeli immigration control) for the long term. In fact, 34 TOKTEN experts, about one-fifth of the total, continued living in Palestine following the end of their TOKTEN assignment. The TOKTEN returnees have come mainly from Jordan and the United States, two countries with Palestinian communities that have kept close ties with family networks in the West Bank and Gaza. TOKTEN participation should be considered quite high for Palestine, which currently experiences a difficult political and economic situation. In Lebanon, where expatriates do not experience similar problems in acquiring residency, only six out of 36, or one-sixth, resettled in Lebanon following the end of their TOKTEN mission.[126]

Finally, the TOKTEN program raises questions concerning the nation-state framework's capacity to deal with brain drain. In an increasingly globalized skill and labour market, developing countries are rarely able to compete with developed countries which offer far higher wages. In such cases, TOKTEN facilitates a

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121 Meyer et al., 1997.

122 For TOKTEN program see Hanafi, 2008.

123 UNDP, 2000.

124 In Palestine, TOKTEN consultants receive US$2,000 if junior and US$3,000 if senior, in addition to paid travel and miscellaneous expenditures.

125 UNDP, 1999, pp. 1-2.

126 Ghattas, 1999.

degree of compensation for countries of origin. In the Palestinian context, such a mechanism can be of vital significance, given the current political and economic situation, which does not encourage (and in fact bars) the homecoming of refugees and members of the diaspora, and where the outflow of skilled individuals is likely to continue.

### C. Network with the diaspora: The PALESTA case

While the return of skilled and professional individuals has been marginal under TOKTEN's low-capacity programs, the ambitious PALESTA network project sought to directly connect a larger group of professionals in the diaspora to the centre. PALESTA, an internet-based network, has as its objective the harnessing of the scientific and technological knowledge of Palestinian expatriate professionals for the benefit of development efforts in Palestine. There are two similar pioneering networks that deal with South Africa and Colombia: SANSA (South African Network of Skills Abroad) and Red Caldas (the Network of Colombian Technologists and Scientists Abroad).[127]

PALESTA's network, a hybrid constructed by the Palestinian Ministry of Planning and International Cooperation's Science and Technology Planning Unit with UNDP support, was launched in 1997. The network includes a database of expatriate Palestinian scientists and professionals and discussion lists for secure discussion among participants as they contribute their technical knowledge and experience in addressing issues of importance to the development of the Palestinian economy. The network functions as a kind of professional gateway, providing current job listings and information on developments in many public, private and NGOs in Palestine, as well as workshops and public events.

Despite PALESTA's ambitious objectives, however, current analysis of this network demonstrates mixed results.[128]

The experience of PALESTA demonstrates the increasing importance of Palestinian professional diaspora networks. PALESTA's electronic discussion list has had a positive effect by providing space for a new experience of community and a rewarding in-gathering that has been diverse and egalitarian. The network has, in a limited way, created a tangible social space that has generated a kind of collective self-conscious for a worldwide professional expatriate community. Communication through PALESTA or a similar network allows mutual identification for actors and allows inferences to be made concerning their associations.[129] However, the virtual community has its limits. A critical examination reveals a tendency, as Wilson suggests, toward "thinning the complexities of human engagement to the level of a one-dimensional transaction and a detaching of the user from the political and social responsibilities of the real space environment".[130] Although PALESTA members number more than one thousand, data suggests that only 20 per cent participate regularly in email exchanges. This technology, however, is not a panacea for the lack of physical connectivity of the Palestinian diaspora. PALESTA's weak overall effect reflects an over-reliance on a technological approach where connectivity is based mainly on electronic exchange, with very few concrete projects launched via the network. Similarly, Gaillard & Gaillard have pointed out out that:

> "[...] the diaspora model will never be a low cost, self-sufficient answer to Africa's scientific needs. Its effectiveness depends crucially on the internal dynamics of the home-based scientific communities. After all, a network of expatriates is at best an extension of a national scientific community, not a substitute. Efforts should therefore, first and foremost, focus on strengthening national scientific capacity particularly training and recruiting the next generation of scientists. If this is not done, the diaspora will only be a smart cloak hiding shabby clothes".[131]

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[127] Meyer et al., 1997.

[128] This assessment is based on the findings of an evaluation study conducted by Sari Hanafi (2008).

[129] Meyer et al., 1997, p. 7.

[130] Wilson, 1997, p. 158.

[131] Gaillard and Gaillard, 2003.

## XI. THREE SOCIO-COGNITIVE CHALLENGES FACING RESEARCH AND INNOVATION

There are three major elements that deeply affect research in the Arab region and which will necessarily be part of any substantial change: the model of development the Arab region wants to adopt, the trust it will put in science, and the conduciveness of the social environment to the development of science. These are not aspects that can be changed by a single policy. In the conclusion of this report we will provide some policy recommendations to address such challenges.

### A. MODELS OF DEVELOPMENT IN THE ARAB REGION

Most Arab countries are rentier economies, ie. rely on income from natural resources (for instance the oil economies, or phosphates for Jordan and Morocco), or from the development of services (tourism in Lebanon and Tunisia) and remittances from émigrés (in Lebanon as well as the Maghreb). These income sources do not to rely on science and research. The commitment to research should be, in this case, based on a certain vision of the future. More generally, science has been viewed as a sort of prestigious cultural activity. The universities were maintained to serve a purpose for the elite, inviting topflight teachers and supporting research for the sake of prestige, but the commitment is unclear. Moreover it does not take into account the formidable pressure on higher education and research as these become necessary to obtaining competitive advantages at the level of the broader society.

Historically, there has been a strong link between the development of science and industrialization. The nationalist Governments that tried to develop import substitution, even when they failed, generally established a scientific base which has remained a national asset in countries like Egypt, Morocco and Algeria. Industrialization may be a greater or lesser priority in some countries, notably those with service economies, but productive activities in information and communication technologies, as well as in traditional industries, require a technological base. Today, this base is much more important than it was 50 years ago: the science that goes into equipment and modern technology relies on skilled labour and a far higher degree of integration between the productive and technological sectors. Using a productive process can no longer be a closed black box of some imported technology. Moreover, the technologies themselves get close to the research in that the type of knowledge needed is today at the molecular (or nano) level. Even simple automatization of productive tasks relies on sophisticated knowledge. Additionally, the management of natural resources for food, agriculture and water resources require greater knowledge input. Thus, even if the industrialization project seems out of date compared to the more fashionable knowledge economy, one should recall that production is indispensible: countries without a local productive base will be swept away in a global competition based on highly skilled knowledge and ‘dynamic’ competitive advantages. This competition is, until now, deeply unequal, more than the industrialization model ever was. The knowledge gap will widen if there are no local productive activities and if skilled locals depart in search of better employment and living conditions.

It must be stressed that (re)building a scientific base is slower and more difficult than destroying one; moreover, waffling between support and suppression of science leaves deep scars. However, under the hammer of the market and neoliberalism, the “national” mode of knowledge production fell into disgrace, and more linkages were established with the market economy. This shift, more often than not, resulted in a withdrawal of state support, and in some cases local scientists found themselves disparaged as parasites or “cultural curiosities”, but not active members of the national productive project. Reclaiming a space for research is one of the steps necessary to achieving a productive development model.

## B. TRUST IN SCIENCE

"Le discours sur la science a été partout légitimé, la pratique de la science, elle, ne l'a pas été"

Jean-Jacques Salomon[132]

There must be a pact (at least an implicit one) between science and society. However, as the above citation from Jean-Jacques Salomon suggests, the discourse on science is easily formulated and legitimized, but the practice of research is more difficult to pursue, given the lack of professionalization of the scientific community and its institutional size.

Since the Second World War, science has been viewed as benefiting the people and generating new, salutary technologies. Among the main results of the Mouton & Waast Comparative Study on National Research Systems, countries with a reasonably strong base were found to treat science as a source of progress for humankind; its support was understood to be the duty of the State; and its results were considered public goods. This applied to the developing world, too, and in the post-colonial era, Governments began building higher education and research centres, with international cooperation and funding and with great ambitions. Scientists organized professionally, but the promised benefits of education and research seemed a long time in coming. In the 1980's, as market economics became the new norm, wellbeing was no longer sought from the State but from private enterprise, and curiously this progress was not particularly favourable to science. Perhaps this was because it changed the status of science itself, from a discipline for the benefit of the State to a discipline with many different potential beneficiaries. In the new model, wellbeing was supposed to come from innovation; but innovation relies on technology, and technology more often than not is based upon research. Moreover, countries confident in research have also been better off developing a sound innovation system – or at least good conditions for innovation to take place. Even if scientific research does not seem directly translatable into commercial products, it increases the capacity of the country to promote innovation. The demand for research, whether from the public sector or, occasionally, from the private sector, is not only low but also directed preferably to "applied" objectives There is a disdain towards basic research, and policy measures usually forget that all research, even when applied or technological, relies on fundamental research. Moreover, useful science is the product of science that is trusted.

## C. THE SOCIAL ENVIRONMENT

The social environment of research is an important component of the motivation of scientists. It is composed of the direct work environment, including career patterns, but also the larger social environment. The job environment of researchers should be scrutinized with some care: trust comes from the scientists' employer (often the Government or "autonomous" public universities). Since most researchers are also in universities, and since universities have been primarily geared toward teaching, research has not been identified as a key priority in their job description. Until very recently, the terms of reference for a university professor in the Arab region did not include research. The latter was an ill-defined activity which could serve the purpose of securing a promotion, at best. Career patterns were (and still are) influenced by the promotion system and it would therefore be advisable to include them as part of Arab university research policies.

Societal and political values are another component of the social environment within which researchers operate, in particular with reference to the role science is given in conceptualizing and planning for the future. Some countries have traditionally held science in high regard, but have failed to give researchers the social standing and means corresponding to this more abstract respect for the discipline. There is a distance between the professed glorification of science and the almost infamous condition for the

[132] Khelfaoui, 2000, p. 5.

research practice: knowledge has certainly been prized, but the locations were knowledge has been cultivated were neither cared for nor championed by concrete policies.

Understanding the value of knowledge is also part of this double recognition as an aspiration, both as part of the nation building project and as a practical endeavour. Knowledge production depends upon its everyday practice, not as a discourse but as an activity. Political power or material wealth may supersede all other aspirations. Religious beliefs, values related to aristocratic ancestry or to the family may exercise similar force. All these factors may well interfere with a commitment to science and its standards. In some Arab countries (and not only is it the case in Arab countries), we have documented examples of self-censorship for religious or political reasons, as well as because of family duties superseding professional obligations. In many places, this has reached the point where practicing research has no other meaning than fulfilling the formal requirements of building one's career. If the research itself is not valued, then science will not prosper.

## XII. RECOMMENDATIONS: A VISION OF THE FUTURE

According to Antoine Zahlan, Arabs have become increasingly aware of their chronic state of underdevelopment in science and technology, thanks to three Arab Human Development reports which advocated for a stronger role for education, greater freedom and the improvement of the condition of women in the Arab region.[133] The controversy raised by the criticism these reports contained of backward education systems and a lack of research triggered intense reflection, which found its way into the 2009 Arab Knowledge Report produced by Al Maktoum foundation. The initial call for greater freedom could have been accompanied by another one: over the last ten years, in every Arab country, scientists and policymakers involved in education and research (very often former scientists themselves) have been trying very hard to transform their research systems. They have tried to do this by creating a space for science inside the political arena and inside their administrations and institutions. They have worked diligently at a very slow rate and have secured, finally, a few small and fragile commitments. Governments usually discovered for themselves that when scientists began working, all sorts of unpredicted benefits appeared. We could write a chapter about how this came about in each country, based on our own experience and that of many interviewed scientists. It would show that the reasons for this engagement with science policy in recent years differs greatly from one country to another, and is interpreted diversely by different social groups. Research policies are not all geared toward promoting the independence and prestige of Arab Governments; there are many other reasons why research has been needed, requested and carried out in the region.

In all cases, it was a movement originating from the institutions, universities, schools, research institutes, and some policymakers (usually technocrats with a longstanding career in public administration), which sought to secure resources for research. In the process, Governments discovered that science is Moreno longer simply a fashionable, cultural and entertaining "social" activity; it is now professionalized worldwide and, more importantly, quite expensive. Some countries outside the Arab region, such as Brazil, Chile, Malaysia, Tunisia, Turkey and South Africa have shown that in a very short time, there can be a spectacular increase in the level of spending on and benefits accruing from research. The question is: is the Arab region ready for such a major overhaul?

In what follows, we will draw recommendations highlighting some challenges to be faced.

### A. MAKING INNOVATION A CLEARLY STATED OBJECTIVE OF PUBLIC POLICY

Business incubators, technoparks or high-tech industrial clusters are not necessarily a panacea, or at least will probably be less of a solution than was initially thought. However, this is not to say that these efforts should be abandoned. On the contrary, these are usually meaningful initiatives and, as far as they serve to connect business practitioners, companies and real markets, they should be promoted and supported. Technoparks are also part of a regional economy, and they cannot function without developing strong links with actual economic and social entities that surround them; thus, they should be included in regional development planning and economic programmes that support local businesses.

It is often claimed that industry expresses little demand for the local university and research community to locally based technical centres. This is only partially true. All innovation surveys conducted so far show that there is innovation going on in ways that are difficult to measure. Morocco and Tunisia repeatedly conducted innovation surveys and it cannot be said that industry does not need R&D or innovation. More than half of the enterprises surveyed had developed innovative projects, but most had been carried out without university participation. Of course, this innovative activity depends upon the size and the sector of the companies. It should be noted that companies headquartered in the country tended to be more innovative than local branches of multinationals (even in sectors such as pharmaceuticals, chemistry and electronics). Success stories indicated that innovation can to be found in larger "medium-sized" companies, defined as around 300 employs, based on long technical expertise fed by continuous improvement in actual markets and interactions with clients and providers.

[133] Zahlan, 2012.

The same holds true for universities. There is abundant anecdotal material in various universities showing strong linkages between teams and companies, based on long-term relationships and expertise. As an example, the Faculty of Science of Saint-Joseph University in Lebanon has a very long history of contacts with the wine industry, the cement industry and the agro-food industry. They have built very strong relationships in these sectors that are funding research inside the lab as well as providing contacts with industrialists. In Egypt, there have been numerous groups of companies in the information and communication technology (ICT) sector that have developed their technological learning based on university expertise. Innovation surveys indicate that these efforts require further development. They have argued that there is no shortage of innovation, only a lack of support. Less that 10 per cent of companies are aware of the support schemes offered by the Government in any of the countries where similar surveys have been done (Egypt, Morocco and Tunisia). It may be that they will develop in the future, as is hoped, for example, with the plan "Maroc Innovation", launched in Morocco in 2012.

The situation today is paradoxical. On the one hand, there is growth in innovation activities, in all kind of companies and even firms that were not interested in this activity several years ago. On the other hand, innovation surveys indicate a low level of interest on the part of the companies in public support for innovation. Companies surveyed mention many reasons for this lack of interest, but two key factors emerge: a lack of information on the support schemes, and little involvement in them. Another aspect is mentioned often: companies show a low level of confidence when the State is involved. One way to re-establish this confidence would be to channel public support through market-based entities that companies can then act on through the market and have a close working relation with the public entities that provide said support. It should also be noted that if the State shows more support for establishing an appropriate legal framework and makes use of resources to promote the participation of the private sector in research, companies will respond better to State initiatives. The State should then show that its interest is not the 'business as usual' approach and that technological development will benefit from exceptional support measures. A preference should be given to collaborative work between technical entities (labs, centres, research teams) and companies. Preference should also be given to companies that wish to develop internal R&D activities. Entrepreneurship is often said to be lacking in the Arab region, which is used to explain the low level of innovation. We believe this not to be the case; rather it appears that entrepreneurship is the region's most abundant resource. What appears to be more difficult is securing regular market support and continuing expansion. The initial investment costs in R&D are probably less focused on research than on development; support schemes should provide for more than "one shot deal" support. Such an effort would require more concerted action between the public entities involved in promoting economic activities. Single support schemes will always be short-term. The sustainable development of enterprise must be based upon innovation, R&D and technological development, areas which should be acknowledged as of special interest to the State.

**Box 6. The network paradigm**

Several Arab countries in the Mediterranean region have made a common turn toward innovation in their S&T policies. Most of their measures try to link research, science and universities to the productive sector. Policy documents insist upon the need for more contacts between academia and the productive sector. Arab countries adopted policies geared toward innovation later than other countries and have been focusing on particular goals, in the absence of an overall strategy for national innovation.

The first visible initiative in most cases was the promotion of technoparks. Tunisia was a forerunner in the region with the El Ghazala technopole in Tunis, mainly oriented toward information and communication technology (ICT). Morocco set up its technopark in Casablanca; Egypt its Smart Village close to Cairo; and in Lebanon, the University of Saint-Joseph created Berytech. These are remarkable in their orientation toward new information technologies, their focus on relatively small start-ups and their coordination between private enterprises and training facilities, such universities or engineering schools. These technoparks have been successful in housing many new small technology-oriented companies. Nonetheless, some assessments tend to doubt the efficiency of the linkage between the universities or engineering schools and departments included in the technoparks (Mezouaghi, 2006).

**Box 6** (*continued*)

Additionally, we can mention a series of common policies in the promotion of innovation around the Mediterranean:

- Technology transfer units in universities and engineering schools
- Funding issues including venture capital, credit schemes, etc…
- Engineering networks
- Promotion of intermediate technical centers
- Business associations related to innovation and technological development

It would be fastidious to detail all the measures that have been taken in order to sustain these initiatives. Suffice it to mention that in the last five years, many countries around the Mediterranean have developed a wealth of instruments and measures with the main aim of connecting businesses with public research centres and universities. Thus innovation has been very much related, in policy terms, to the development of techno-economic and engineering networks. Networks are mentioned in the policy documents as an efficient means for promoting technology to businesses.

It might be necessary to insist on the fact that this emphasis on techno-economic networks is not the only possibility for innovation policies. Other possible orientations could have been the development of businesses with a strong (public) investment component, a preferential policy towards international investors, or the development of strong public technical centres.

The network orientation certainly has the advantage of flexible arrangements. It is also strongly inspired by innovation policy concepts developed in Europe, and specifically France. Finally, it has the additional characteristic of challenging the public research sector by asking it to establish linkages to the economy without endangering the institutional and political position of academic institutions.

These policies aimed at promoting networks are too new to have received an impact evaluation. What is at stakes is the creation of a whole set of new actors (units of technology transfer, start-ups, incubators, technology poles, science parks, etc.) in between firms and public authorities

For more information, see Arvanitis, R., M'henni, H. "Monitoring Research and Innovation Policies in the Mediterranean Region". *Science, Technology and Society*, 2010, 15 (2), pp. 233-269.

## B. RESEARCH SYSTEMS: DIVERSIFICATION AND SCIENTIFIC PRIORITIES

What kind of science systems are needed in the Arab region? Given that the research landscape in each Arab country is fragmented and small in scale, it is debatable whether one can talk of a science "system" in many of these countries, as they do not exhibit typical systemic characteristics.[134] For example, institutions are not typically aligned through input, process and output flows, and there is no systemic behaviour in response to external changes and demands. Rather, the image of an "assemblage" of fragile, somewhat disconnected and constantly under-resourced institutions is perhaps a more apt metaphor to describe the science arrangements in most of these countries. Here we would like to raise two issues for the future: the centralized vs. diversified model and the issue of research autonomy.

Among the research units, there is a variety of research activities that can be developed. As research activity grows, all countries experience a certain level of diversification. What can normally be found in a good research system is usually a wide range of specialists. But when the overall number of scientists is small, there may be a situation where you find one or two specialists in each area. They usually feel quite alone and few among them would have the capacity to sustain a large team of specialists over time. Small research systems must then confront this situation, and often experience difficulty in forcing the creation of larger teams.

[134] Mouton and Waast, 2009.

This issue is a complex one and there are many ways of dealing with it. The institutional complexity of a research system always poses a dilemma. As a way to offer a sound proposal for discussion, one should examine the type of funding that would be drafted according to priorities. "Priorities" is not a very good term since it harkens back to the 1970's, when national planning was fashionable. Moreover, recent exercises in priority-setting in Arab countries have tended to produce a catalogue, which is possibly relevant but not feasible with local resources. A very good example is the Science and Technology and Innovation Programme (STIP) designed by CNRS in Lebanon. It is an excellent programme, but no funding was available at the time it was drafted.

An alternative way of tackling the funding issue would be to draft a catalogue not on the basis of declared priorities (whatever forecasting exercise be used) but by combining these declared priorities with actors funding them. It is not our purpose here to detail this exercise, but it would be interesting to have a real forecasting exercise that combines the possibility of actual actors in the field. A possible differentiation would be as follows:

- Few strategic funding programmes with strong linkages to the productive sector. The pursuit of some programmes, which imply energetic support from the State in areas considered "strategic" and applied research, where the public authorities promote active collaborations or "clusters" with dynamic firms. We have already mentioned this aspect above. It is necessary here to add that funding would then be given priority when the alliances and collaborations are made. The areas for funding are well known: water, desertification, renewable sources of energy, and agro-food. Areas linked to the promotion of a knowledge economy could also be prioritized. The main evaluation criteria would be the programme's relevance to the local economy and the level of linkages to the productive sector.

- Promotion of some research areas with clear socio-economic objectives that are specific to the country, where users and social actors are present, and where economic interest is not the first objective, for example health. It is good to remember that in some countries, university incubators in areas not considered "strategic" have been very commercially successful. As the Lebanese CNRS has stated, "if you consider health-related research a cost, consider disease!" What is needed is some support to these areas, which are not immediately profitable, but where interaction with final users is of paramount importance. Consider for example, the construction industry which has developed its new building materials based on intense exchanges between the companies that build, those producing the material and designers and architects. These areas related to real users could also recollect and use local knowledge, for example in agriculture, medicine, pharmaceuticals and fisheries. 'Traditional knowledge' is better introduced into research and new developments when it is linked to communities that use this traditional knowledge. The main criteria here would be relevance to social needs and the creation of strong teams.

- Areas of basic sciences. These are areas where collaboration with foreign colleagues will be actively sought out, where the objective is neither socio-economic, nor driven by innovation. The rationale for such programmes is that a country, as small as it may be, needs to have an eye open to developments made elsewhere. If C. Wagner is right, the smaller the country the more beneficial this linking to foreign research.[135] Doctoral students are a good investment if interesting employment schemes are devised for them following the completion of their studies. We should add to Wagner's proposal that his strategy should not only be related to domains with an existing local productive base (such as hospitals), but also to the "domains of the future". Excellence and novelty should be the main evaluation criteria.

[135] Wagner, 2008.

All these strategies require funding, which could be distributed through many different schemes: scholarships to students working with companies, funding of collaborative projects, direct subvention to research projects, etc. Two aspects of the experience of many countries bear repeating:

*Identify research*: Research needs to be clearly identified and not only included into larger objectives like industrialization, provision of food or healthcare and other socio-economic objectives. Public budgets should clearly identify research as a goal. If not, a powerful alliance of misunderstanding and economic interest will always eclipse it.

*Stabilize teams*: Funding should go to teams, not individuals. Building teams takes time. Very short-term research assignments can kill teams, which have to adapt quickly and respond to the offer, and function as consultancies instead of consolidating their human resources and equipment. This is why funding should not come only in the form of project funding under competitive schemes, but should also offer a stabilizing mechanism, a system that permits the maintenance of quality research and at the same time grow its own resources. The experience of the Tunisian 'labelisation' system (label as research teams specific entities and link a specific funding to a specific roadmap presented by this research team over a four-year period) is perhaps the best example, since it generated a stable increase in research activities over a very short time in Tunisian universities.

## C. CONSOLIDATING TEAMS

We have already insisted on the importance of funding schemes. Before closing this chapter, we would also insist upon a possible suggestion for the "stabilizing" mechanism or the "unifying" mechanisms discussed in the previous section. In effect, naming "clusters of activities" is not a sufficient strategy to induce the creation of strong teams around specific objectives. A mechanism is also required to guarantee regular funding on the medium-term, and not exclusively from outside sources. The Tunisian experience here could be examined in more detail. This mechanism needs to be driven by both universities and central state institutions which can guarantee the validity of the "team projects".

Research in a social and economic environment that shows little interest in research is possible. The American University of Beirut is a good example; Lebanon does not boast an environment particularly conducive to research, but nor has it been hostile to scientific innovation. Still, no real incentives for research exist, with the National Council for Scientific Research historically supporting pre-existing research areas rather than promoting new ones. Usually, these areas of research have arrived in Lebanon through Lebanese professors returning from France or the United States and developing research activities alongside their former European or American colleagues. International cooperation is thus the main tool of consolidating a competence: it does not permit however the development of its own basis of research themes of greater local relevance. Biomedical research at AUB grew in this manner and in a symbiotic relationship with the medical practice at the university hospital. Thus, the professionalization of medicine entailed conducting research. This is not the exception but the rule, as can be shown in other universities and university hospitals in Lebanon. One of the researchers we interviewed at USJ, who has an impressive record of publications, described himself as a doctor, not a researcher, and he mostly promotes a research team, not an individual practice. He developed an area of expertise that is unique in the world and specifically relevant to Lebanon, where medical diagnosis and lab research co-exist.

We can try to generalize from this example by saying that lack of professionalization in specific activities is part of the riddle of research. The more professionals there are the more research will be required. When professionals become more demanding, research gains in importance and value. This is how contacts have been built between companies and universities in many countries; but this contact does not happen through funding alone.

In the late 1970's, when the research system in Brazil was beginning to grow, a Brazilian sociologist conducted a series of interviews with researchers in many fields under the title "Islands of Competence".[136] This is a most accurate description of the situation in many Arab countries: a series of islands of competence, niches of peculiar expertise which have been built or are being built. These islands are relatively independent of one another, even in similar domains. They will objectively seek the best expertise and will avoid local competition. They will also play on national pride as a means of securing funding. Local networking will be avoided. This experience was common to most Latin American countries during the 1980's and 1990'sNew institutions were created, geared towards creating bridges between productive entities and universities. However, these countries, like Tunisia some ten years later, created "national systems of research" that served mainly as promotion systems, identifying and consolidating the research activity of individuals. These evaluation structures of research funded an additional incentive for good publication patterns. Universities adopted similar schemes. Brazil, in contrast to Mexico and Chile, adopted incentive schemes that were collective rather than individual. Today, this gives Brazil a decisive advantage in research.

These evaluating/labeling schemes, which take a series of forms, have been strong instruments for the promotion of research. They benefit research for many reasons, including the fact that they allow for the clear identification of specific activities related to research. They may also lead to better living conditions for researchers.

### D. Interacting with others: International, regional and local networking

All the studies and interviews we have had access to show that there are very few synergies between different scientific institutions at either the national or regional level: joint projects between Arab scientific research institutions working in similar fields remain extremely rare, even within the same country.

It is clear that scientific networks at the level of sub-disciplines could be promoted and that resources from Gulf countries would be useful in that effort. Many reasons make us doubt on the feasibility of programmes at this level, drawing upon the experience of the European Union. The framework programmes, established in 1984, had the purpose of supporting European research projects that combined different teams from different countries. This worked surprisingly well and quickly. It should be said that, at that time, funding for research in European countries was usually done by regular budgetary provisions to research institutions, whereas the EU was proposing to fund projects through competitive calls.[137] Nonetheless, the EU "framework funding" came in handy and worked well, among other reasons because the European Commission's research activities were parallel to that of the Construction of European institutions in other areas (economy, agricultural funding and so on). Moreover, the Framework programmes obliged national research system to be internationalised at least within the boundaries of Europe. In the case of inter-Arab cooperation, there is little international cooperation and research is isolated in this endeavour. Additionally, a recent evaluation of the EU 7th framework cooperation shows that EU funding to non-EU partners (possible since the 5th framework programme in practically all areas and since the 6th in all programmes of the EU) is quite low. International cooperation with non-EU partners is basically done through funding directly with European partners. More than 400 million Euros have been distributed to projects involving Mediterranean partner countries; the partners in Mediterranean countries in these projects received approximately 10% of this total funding. Bilateral programmes may prove more efficient, and it should be remembered that European countries have not abandoned their bilateral funding of research and higher education in neighbouring regions. France, Italy, Spain, Germany and to a lesser extent the United Kingdom have been active in funding research through bilateral programmes in the Arab region. Even the best ideas for realizing the full potential of the region, through the use of funding from the Gulf or any other source, does not make sense if not accompanied by a policy with stated objectives. Having said that, despite the fact that Inter-Arab cooperation is quite low, more funding is available and we believe that only time will tell if the increasing

[136] Oliveira, 1984.

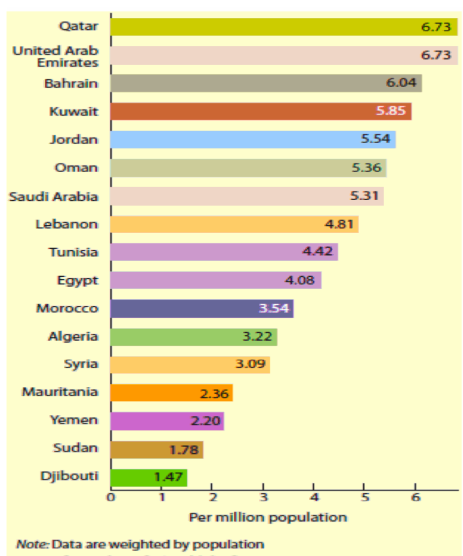
[137] The exception was the UK research councils that were funding a lot of their research through competitive calls inside UK.

money from institutions such as the Qatar Foundation will fill the gap. The once-stated objective of 'national self-reliance', whether referring to individual States or to the pan-Arab ideal, is probably best forgotten. Rather, we believe that the driving force behind the development of research in the region will not be funding so much as the professionalization of funding mechanisms. For example, the Qatar Foundation's support for medical research has been appreciated by the research teams involved because of the seriousness and professionalism of the evaluation mechanism. As one researcher said, "they had done their homework, and they select very good teams". Funding research is a profession, and there is a clear need for transparency and professional regulations for the use of money from competitive funds. It is also clear that no research will ever grow satisfactorily if the internal mechanisms currently in use by most institutions for spending external funds are not modified. Today, the problem is less a lack of funds than a lack of management capacity to spend them. It would be our recommendation to promote systems of management for research and innovation, and make them a topic of high priority for training in the near future.

A closely related issue is the fact that networking as an objective of funded projects is very efficient. Again, the experience of the European Union Framework programmes shows the strong capacity for more research and better-oriented programmes as a result of networking. Projects that are by themselves small networks always tend to expand in order to interest larger networks. The professional networking is thus particularly efficient and grounded in the actual practice of research. There is no reason why this kind of networking wouldn't work in specific professional areas. Again, this seems possible only at the level of disciplines or specific subjects.

This kind of 'linking' strategy, which is based on exploiting the networks of research, would make sense if it permits relatively strong research teams to participate. Participation in international collaborative networks without a parallel consolidation strategy would be like entering a river; it will end by dissolving in the sea. Strong poles of the network that bring together many researchers working on the same topic would be able to profit from the flow of resources. Networks are not a sufficient strategy; they need to be complemented by the consolidation of teams as discussed above. This consolidation seems impossible without state support and intervention. The motivation and form of state participation can vary a great deal: it can range from the routine management of public institutions conducting research on a centralized model (Tunisia) to the fostering of a multiplicity of universities with no common regulatory framework (Lebanon). This is different from the way the World Bank has promoted the "knowledge economy".

**Figure 20. Knowledge economy in the Arab region**




*Source*: UNESCO, 2010, p. 269.

The World Bank has indeed designed a Knowledge Economy Index (KEI) and a set of policy recommendations for the future based on the liberalization of the economy: more S&T, more innovation, more entrepreneurship, more privatization, more flexible markets, and less state control (figure 20). This model has ranked Arab countries in such a way as to champion Qatar and the United Arab Emirates as models of Arab knowledge economies. We advocate for a more diversified model, which would take into account the various types of sciences and the different roles played by the State, depending on the issue being addressed.

### E. MAKING RESEARCH A POLITICAL TOPIC

During the Arab Summit in March 2010, the Heads of State in attendance adopted a resolution mandating the General Secretariat of the League of Arab States to develop a S&T strategy for the entire Arab region, in co-ordination with specialized Arab and international bodies. This strategy was to be submitted to the 2011 Arab Summit for adoption, and was expected to address the important issue of facilitating the mobility of scientists within the region and to enhance collaborative research with the sizeable community of expatriate Arab scientists. Both the strategy and the subsequent Arab Science and Technology Plan of Action (ASTPA) will be drawn up by a panel of experts from the region, with the institutional support of the Arab League Educational, Cultural and Scientific Organization (ALECSO), the Union of Arab Scientific Research Councils and UNESCO, among others. ASTPA will design both national and pan-Arab initiatives in 14 priority areas, including water, food, agriculture and energy. It is also expected to recommend the launch of an online Arab S&T observatory to monitor the S&T scene in Arab States and highlight any shortcomings in implementation. One of the keys to implementing measures at the country level will be identifying the challenges that Arab countries face at the domestic level and establishing research as a stand-alone topic for political discourse. Political support for research and innovation at the highest level is required, coupled with affirmative government action, an upgrade of existing science, technology and innovation infrastructure and an increase in GERD.

At the same time, lessons learned from the experiences of several countries in Latin America suggest the importance of connectivity at the level of institutions and of individual researchers. Thus both top-down and bottom-up approaches are required.

### F. REFEREED ACADEMIC JOURNALS

The Arab region is in need of more journals to publish scientific results. The objective should be to create a culture of exchange between members of the scientific community locally and to mobilize peers, the public and decisionmakers. It should be noted that the main dynamic behind the publication of journals is the existence of a lively scientific community. Large publishing companies such as Elsevier and Kluwer have taken strong commercial positions, making the scientific community an instrument of commercial objectives. With the advent of Open Science, strong protests have emerged from working scientists that have used the force of ‘social digital networks’ to mobilize the community giving way to a renewal of peer partnerships. The Arab region could profit intellectually from this movement; it should also encourage publishing in Arabic when (and only when) there is a group of scientists demanding it. The main difficulty here is that, for reasons that are purely institutional, universities have a tendency to promote departmental journals. These are strongly ‘endogamic’ journals, publishing articles only from the personnel that belong to the university. In very large universities this may make sense; it is an absolute waste of time in smaller ones. Journals are better defended when they belong to a specific disciplinary group, focused on some very precise topics or on broader disciplinary areas, if the persons who want to defend the journal feel the need. Moreover, universities and science councils should defend the popularization of science. A massive effort should be given to create a wider audience for science, technology and innovation by creating lively journals, websites, films, documentaries and other tools for the dissemination of scientific and technological activities. Citizens should not be left in the dark about what happens in the laboratories, schools and universities of their own country.

## G. DIASPORA OPTIONS

As demonstrated in the section on brain drain and brain gain, there are many lessons to be learned from the two Palestinian experiences highlighted, namely the TOKTEN programme and the PALESTA network. It is extremely important for international organizations to encourage networking with the diaspora and the temporary recruitment of scientific expatriates to work or volunteer in their countries of origin. Every Arab country stands to benefit from similar initiatives, which cost little to run but have the potential to harness development in the Arab region.

## XIII. CONCLUSION: FIXING THE CYCLE BETWEEN RESEARCH, UNIVERSITIES AND SOCIETY

The major issue revealed in this report that the cycle between research, universities and society has been broken. The results of this disconnect have varied depending on the domain of economic, political or social life under consideration. For instance, Arab countries have small patenting rates. This is usually used as a reason to conclude that more patenting should be encouraged. Policies have been designed that are supposed to promote the development of research into patents; however this is only a small part of the more general issue of connecting research to the economy and society. As we mentioned when discussing the various functions of research, there is an insufficient appraisal of activities that are not directly linked to the production of scientific articles and books

One of the most important aspects of the broken cycle has been the working conditions of researchers within their institutions. Most researchers in Arab countries belong to universities, and their primary responsibilities include teaching. Generally, these universities do not support their research activities. There will be no real progress if universities do not actively promote research in their own teams, within their own departments and faculties. Action here will necessarily be related to creating internally funding research opportunities, both for individuals and teams. External funding administrative support for the development of research activities will also be necessary. In many universities in Morocco, we have been told that the use of external funding by the actual research teams is close to impossible. This is true for all kind of research.

In many universities in the Arab region, the vast majority of faculty are hampered by heavy teaching loads and capacity building for the institution where they work. One faculty at Aleppo University pointed this out clearly: “I stayed 12 years in Japan and I published 12 articles. I came back to Aleppo, and I have not produced a single article in the 12 years since my return [...] I have done a lot of teaching, capacity building and obtaining projects for the university”. In the absence of support from institutions, research will always be a marginal activity.

Research has also been too narrowly related to the individual promotion of professors. In this case, ‘research’ has acquired a distorted meaning, since its only significance is its reception by colleagues and the university administration, and only for a specific person. On the contrary, research should be promoted as a collective endeavour, with shared activities and common working plans.

Another important aspect related to the institutional capability to support research is the existence of post-doctorate fellowship and grants, which are rare in the Arab region. For instance, according to our survey of research practices, very few Lebanese members of the American University of Beirut’s faculty have benefited from post-doctoral fellowships; those who have completed their fellowships outside the Arab region. Meanwhile, at the largest university in Lebanon, the Lebanese University, no post-doctoral system exists, a situation common to many other universities. Many Arab universities give grants for research only to full professors, who are normally over the age of 50. One professor of Biology in her early 60s at Cairo University declared in an fieldwork interview that “now that I am a full professor, I can begin research!”. There is a great deal of room to increase support to young faculty by promoting fellowships. None of these measures can be of any success if both funders and employers (in this case the university administration) are not involved in a common strategy.

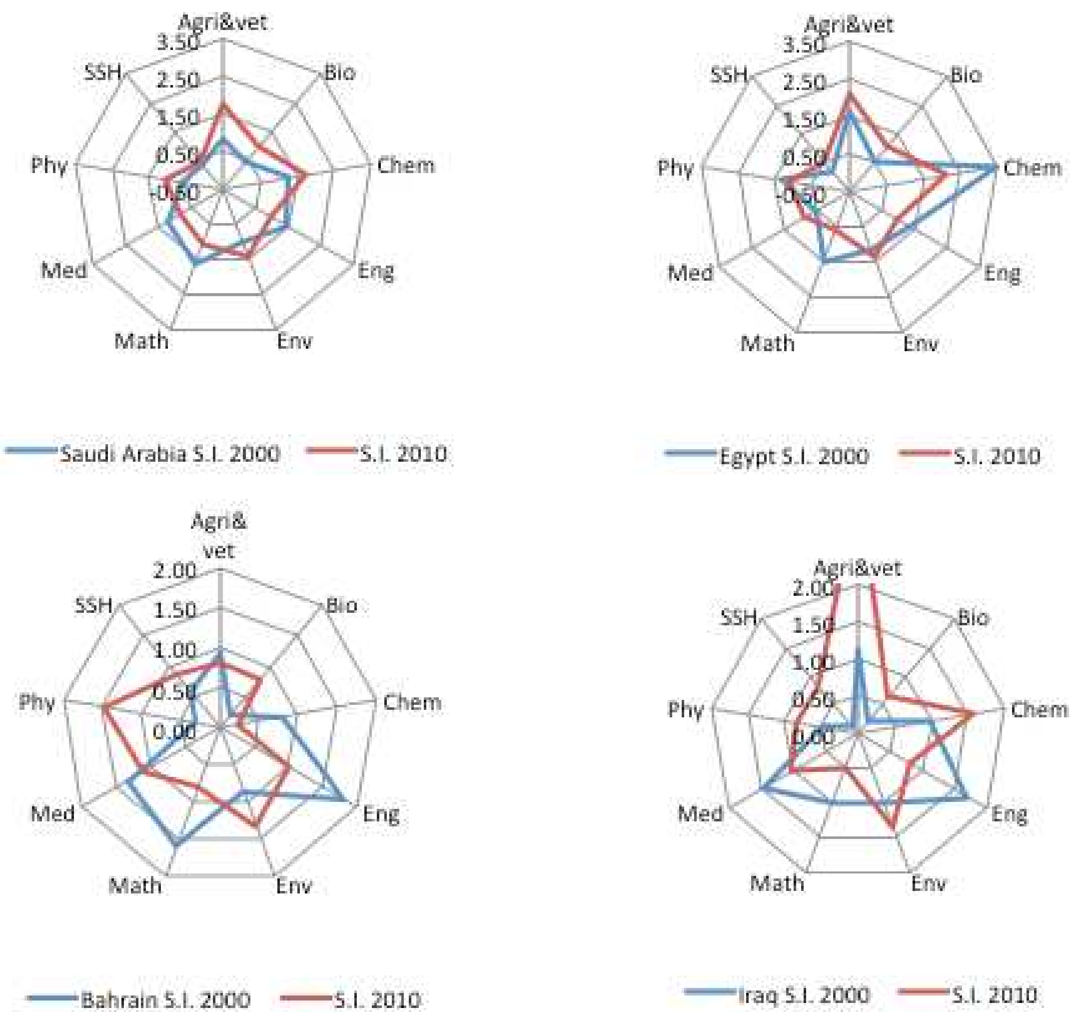
Finally, in universities, a large part of the research activity should be included within the general framework of the Master’s and PhD programmes. These need to be designed in such a way as to lead to research, in particular for PhD programmes. There will be no research-efficient faculty if they cannot relate the teaching activity of PhD seminars to research orientations. Moreover, the use of cooperative or shared doctoral programmes with foreign universities could be a lever for more research in the university environment. France has designed “sandwich doctorates” with double diplomas from French and foreign institutions, and these have been received quite enthusiastically by both French universities and their partners abroad. They also have the advantage of promoting long-term relations between teams in both countries.

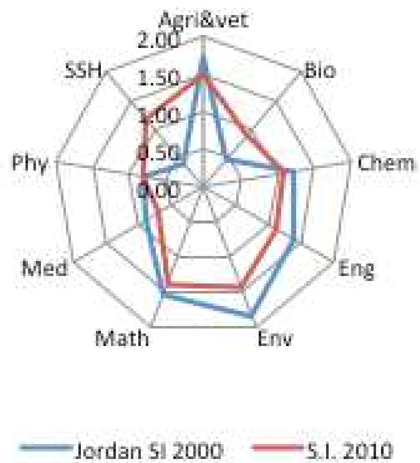
Annex

**BIBLIOMETRIC INDICATORS ARAB REGION**

This annex present all the bibliometric indicators per country used in the report when Scopus is used as a reference. We have selected three indicators: total production, world share and specialization index.

**Figure 1. Specialization Index in Arab Countries (2000-2010)**




Agri&vet
Bio
Chem
Eng
Env
Math
Med
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SSH
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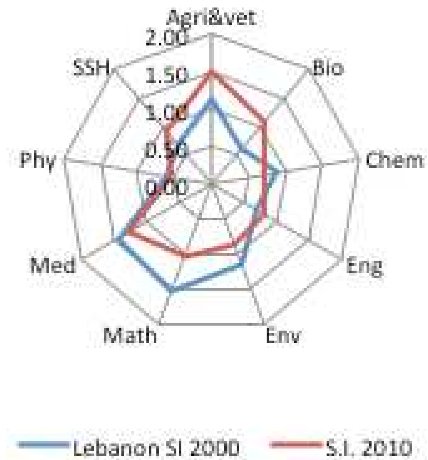
Jordan SI 2000
S.I. 2010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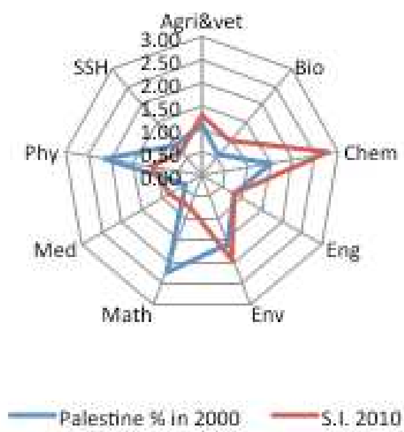
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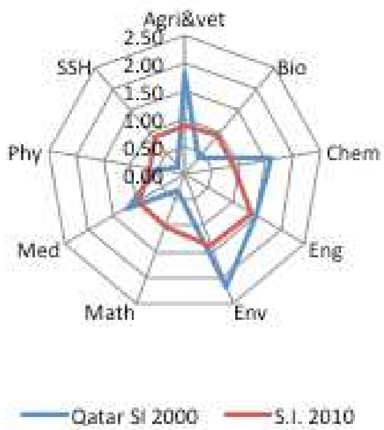
Palestine % in 2000
S.I. 2010


Agri&vet
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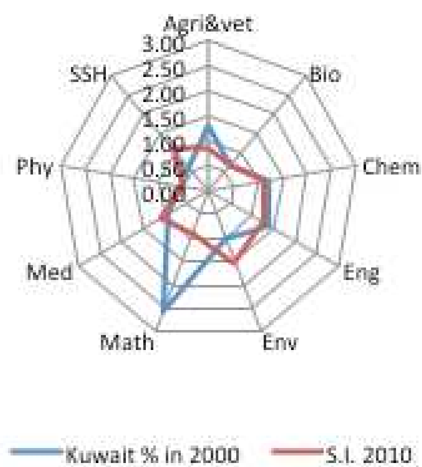
Qatar SI 2000
S.I. 2010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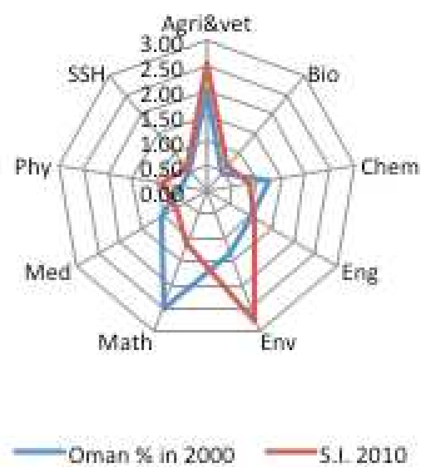
Kuwait % in 2000
S.I. 2010


Agri&vet
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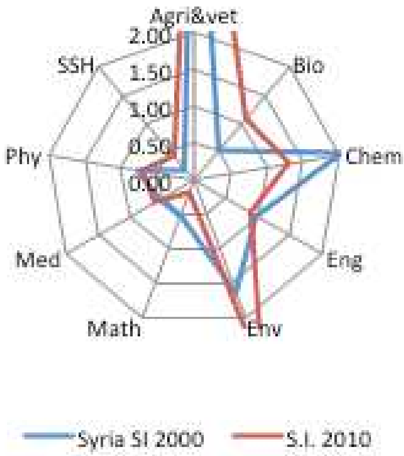
Oman % in 2000
S.I. 2010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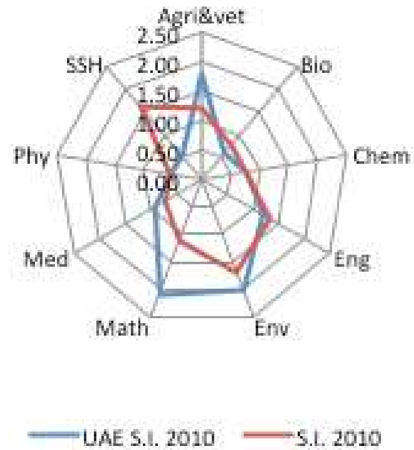
Syria SI 2000
S.I. 2010


Agri&vet
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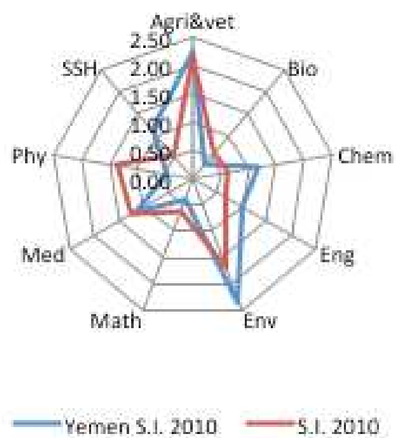
UAE S.I. 2010
S.I. 2010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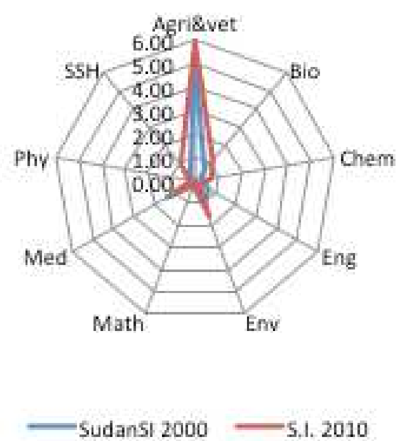
Yemen S.I. 2010
S.I. 2010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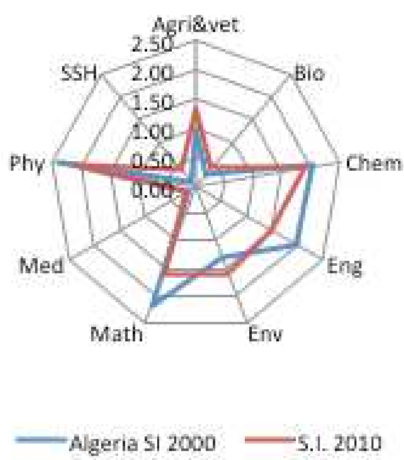
SudanSI 2000
S.I. 2010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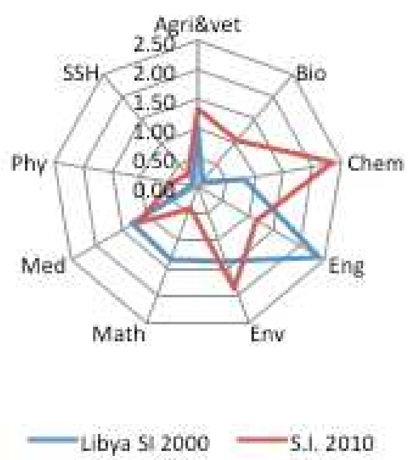
Algeria SI 2000
S.I. 2010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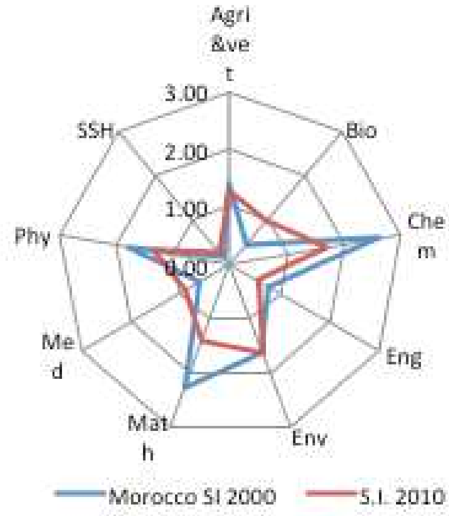
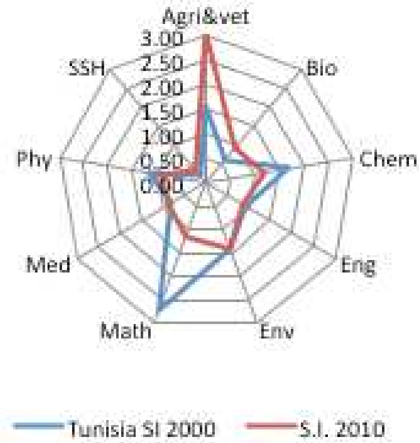
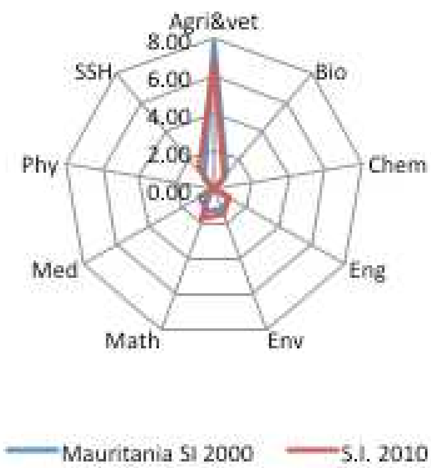
Libya SI 2000
S.I. 2010



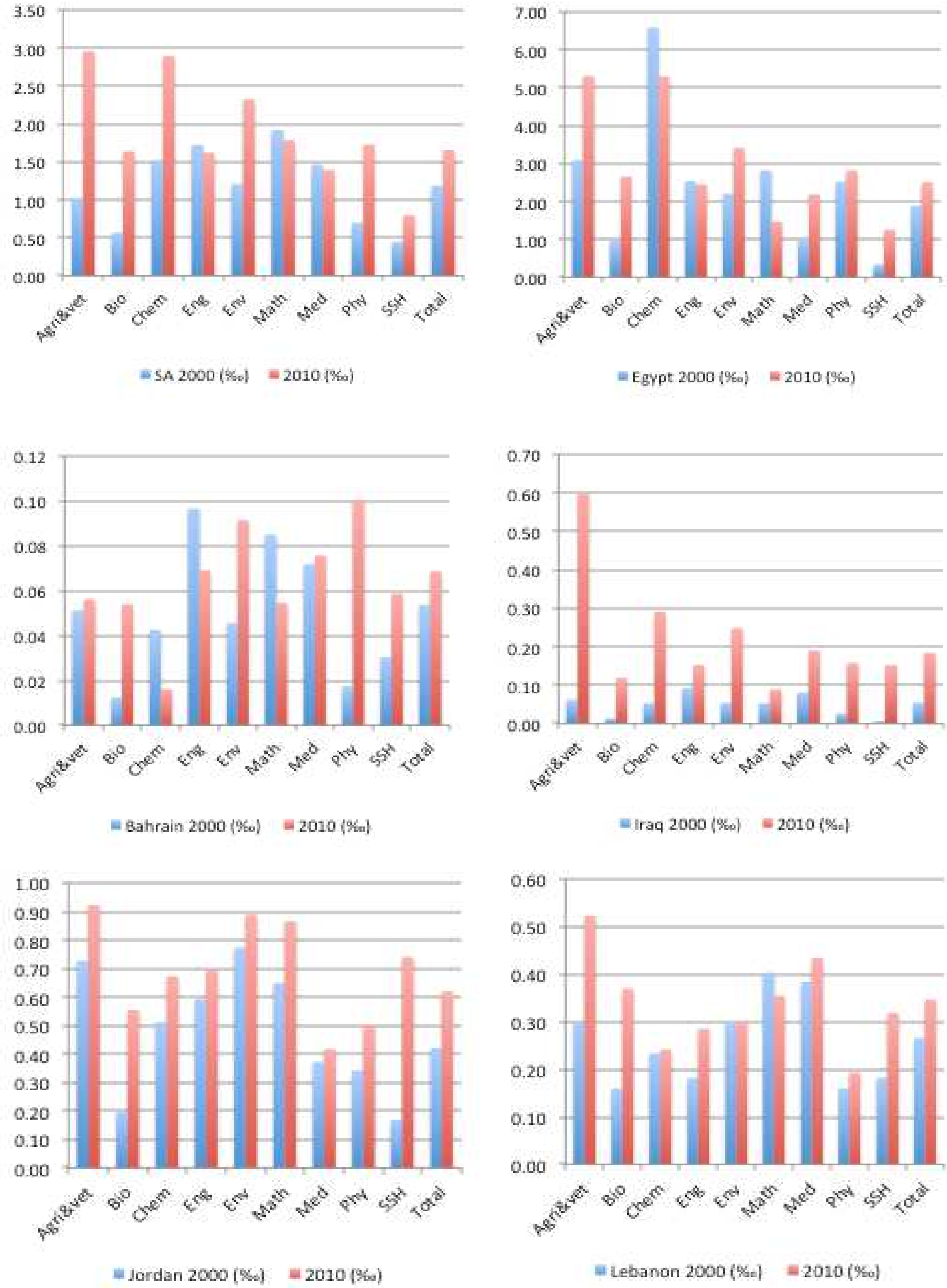



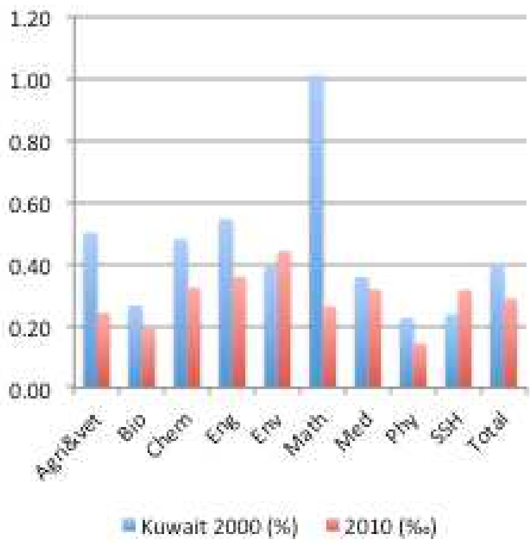




*Source*: Own elaboration, Scopus data delivered by http://www.scimagojr.com/.

*Note*: Specialization index=1 when activity in the domain is similar as the country's activity in the world production; above 1 there is a specialization in the specific domain; below 1 there is less specialization.

**Figure 2. World shares in each scientific domain (% from the total publication) in Arab Countries (2000-2010)**




Agri&vet
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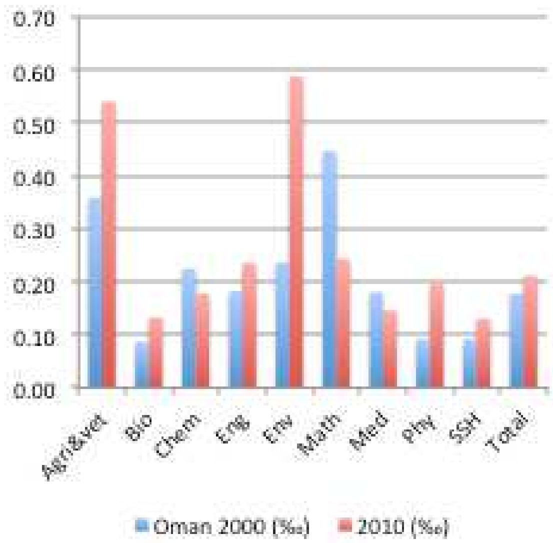
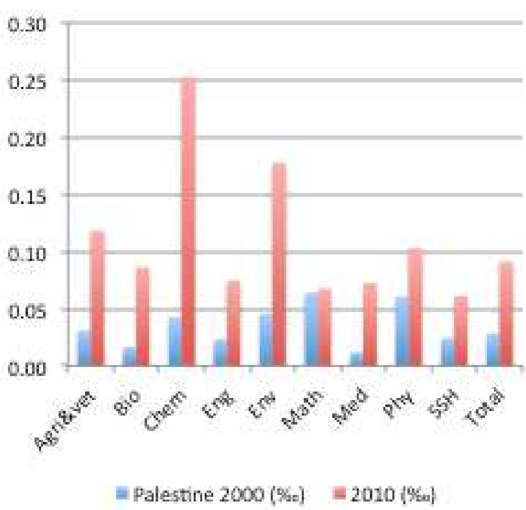
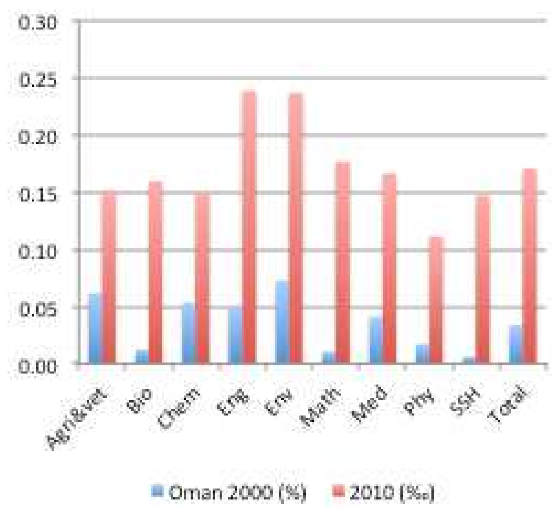
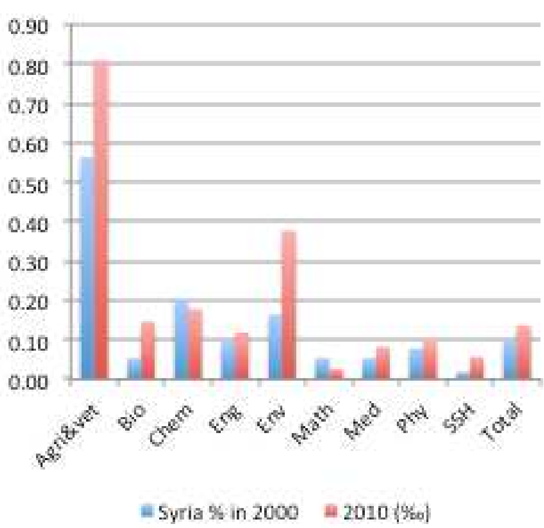
Eng
Env
Math
Med
Phy
SSH
Total
Kuwait 2000 (%)
2010 (‰)


Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Oman 2000 (‰)
2010 (‰)


Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Palestine 2000 (‰)
2010 (‰)


Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Oman 2000 (%)
2010 (‰)


Agri&vet
Bio
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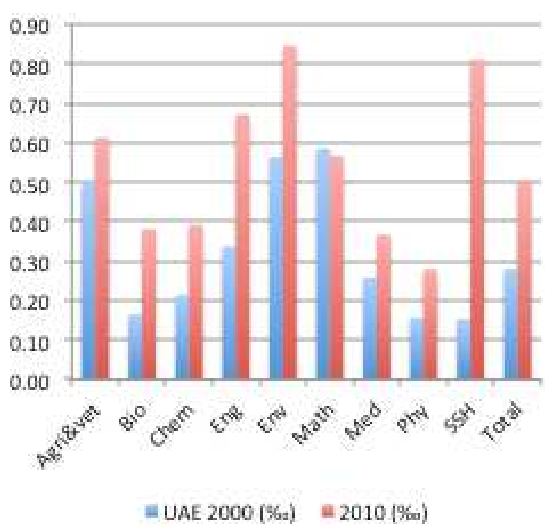
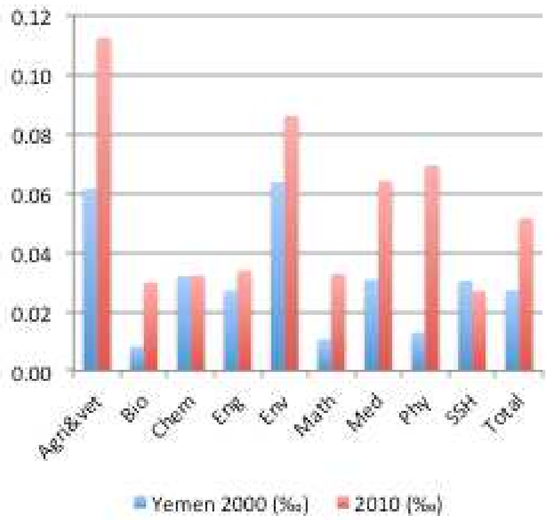
Eng
Env
Math
Med
Phy
SSH
Total
Syria % in 2000
2010 (‰)


Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
UAE 2000 (‰)
2010 (‰)


0.12
0.10
0.08
0.06
0.04
0.02
0.00
Agri&vet
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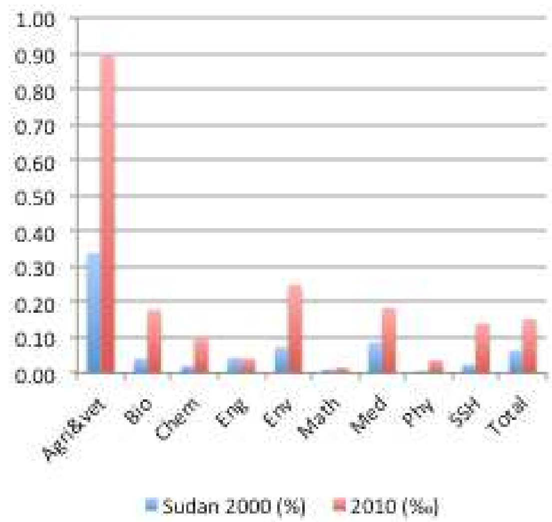
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Yemen 2000 (‰)
2010 (‰)


1.00
0.90
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0.70
0.60
0.50
0.40
0.30
0.20
0.10
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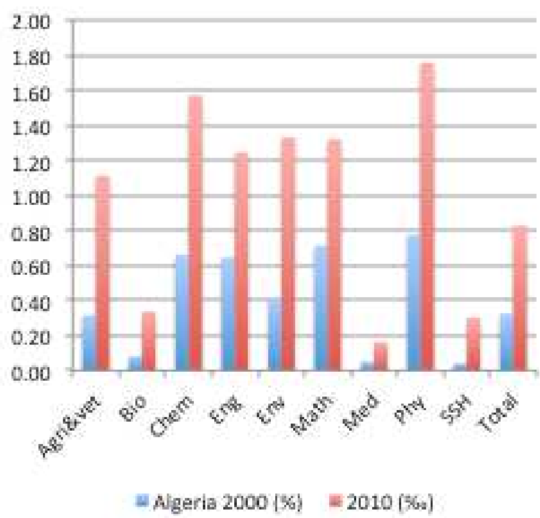
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Sudan 2000 (%)
2010 (‰)


2.00
1.80
1.60
1.40
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1.00
0.80
0.60
0.40
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Bio
Chem
Eng
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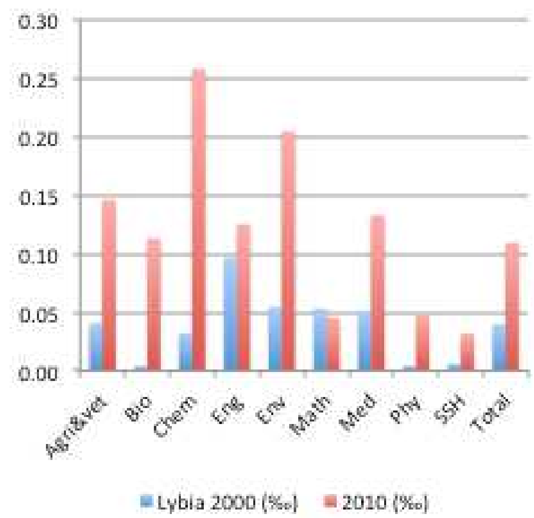
Math
Med
Phy
SSH
Total
Algeria 2000 (%)
2010 (‰)


0.30
0.25
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0.15
0.10
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Agri&vet
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Chem
Eng
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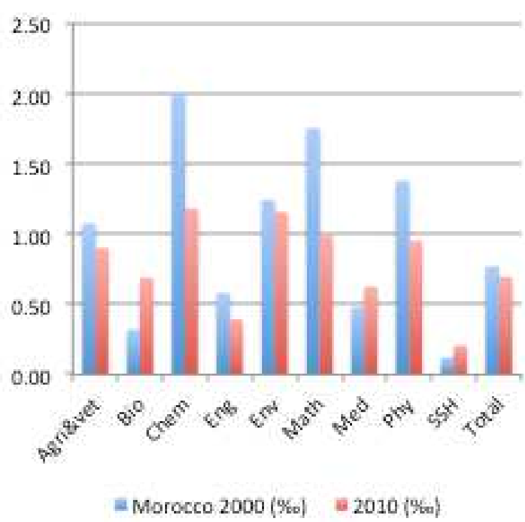
Med
Phy
SSH
Total
Lybia 2000 (‰)
2010 (‰)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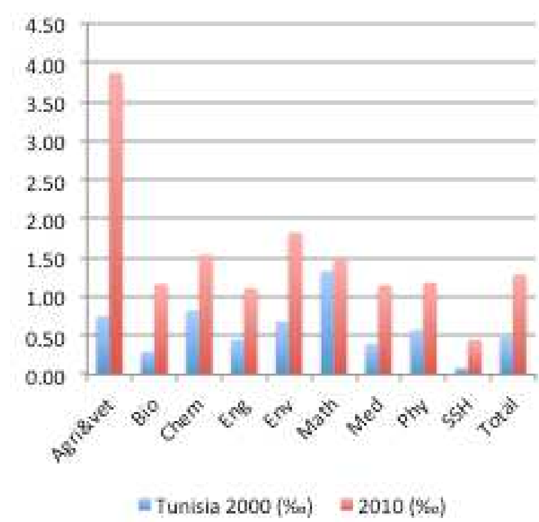
SSH
Total
Morocco 2000 (‰)
2010 (‰)


4.50
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1.50
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Agri&vet
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Eng
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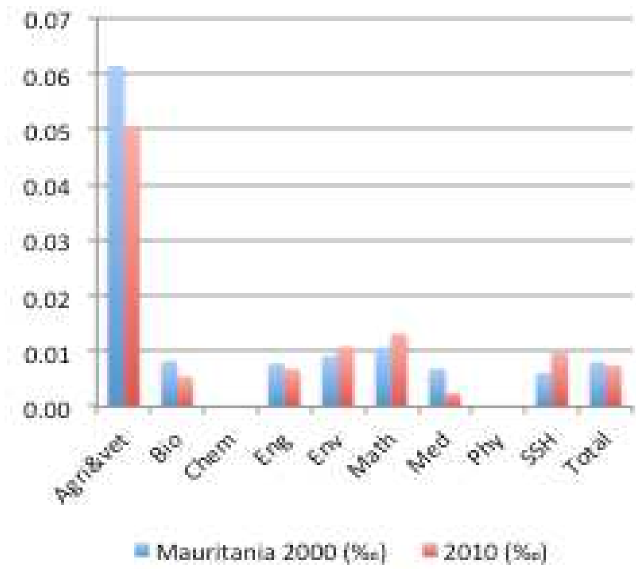
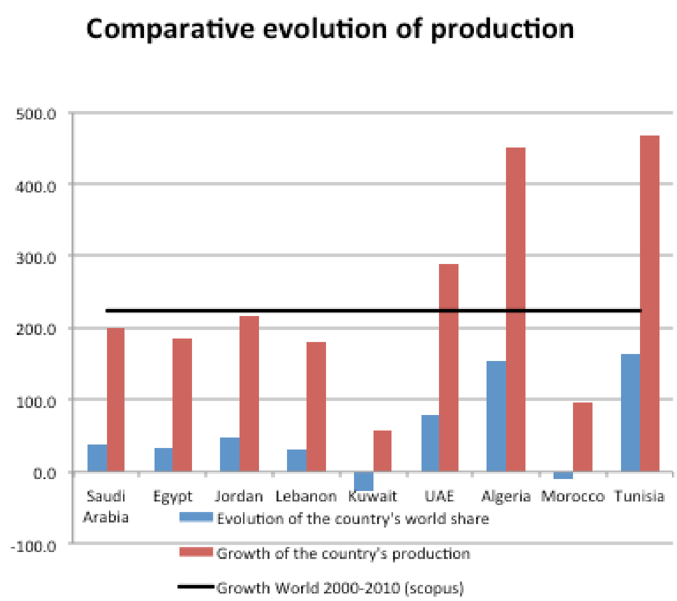
Math
Med
Phy
SSH
Total
Tunisia 2000 (‰)
2010 (‰)




*Source*: Own elaboration, Scopus data delivered by http://www.scimagojr.com/.

**Figure 3. Comparative growth of each country's world share, country's production (2000-2010)**




*Source*: Own elaboration, Scopus data delivered by http://www.scimagojr.com/.

**Figure 4. Comparative evolution in Agricultural sciences, Veterinary and Biological Sciences**

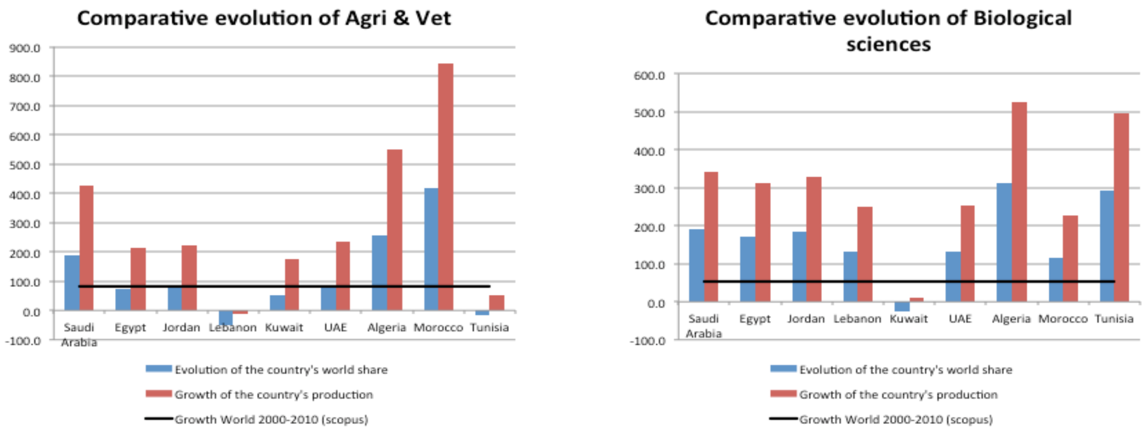



**Figure 5. Comparative evolution in Chemistry and Engineering**

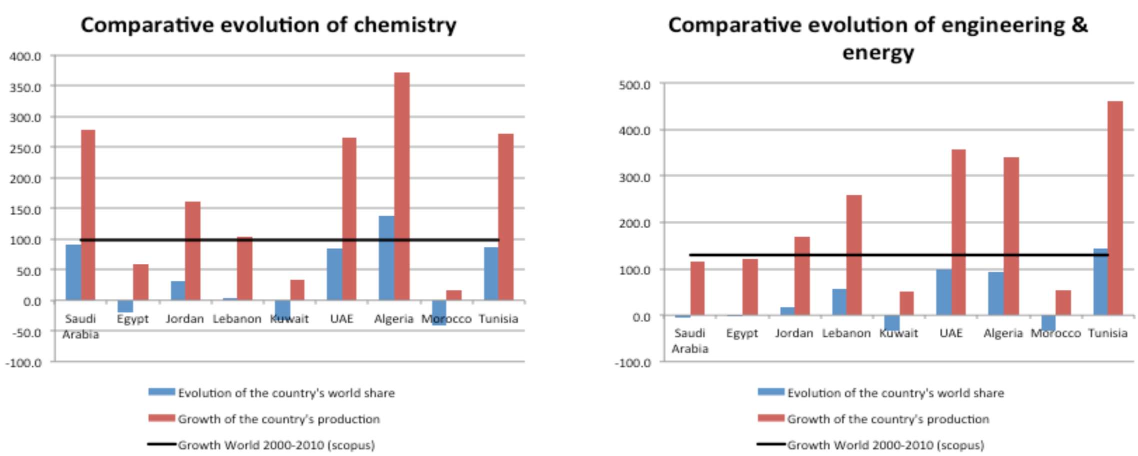



**Figure 6. Comparative evolution in Mathematics, computer sciences, and Medical sciences**

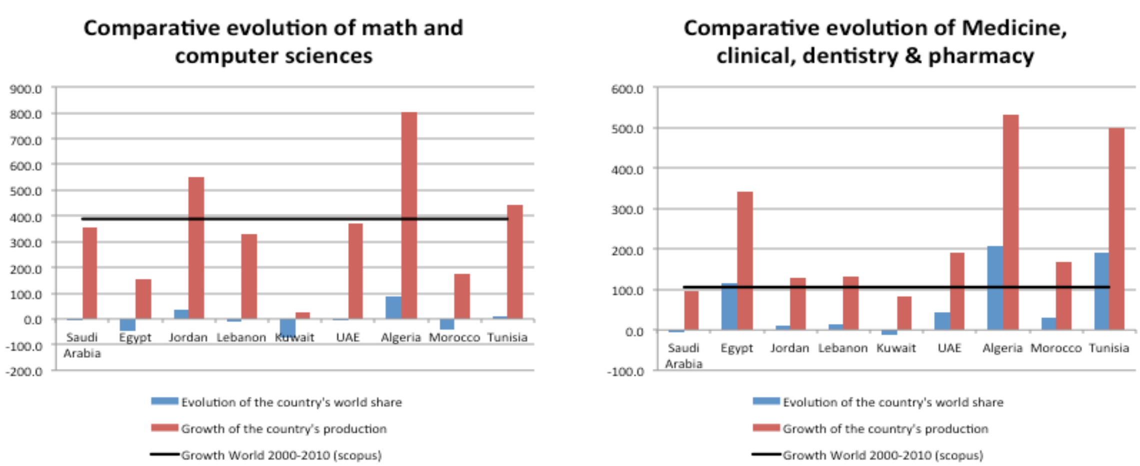


**Figure 7. Comparative evolution in Physics and Social Sciences and Humanities**

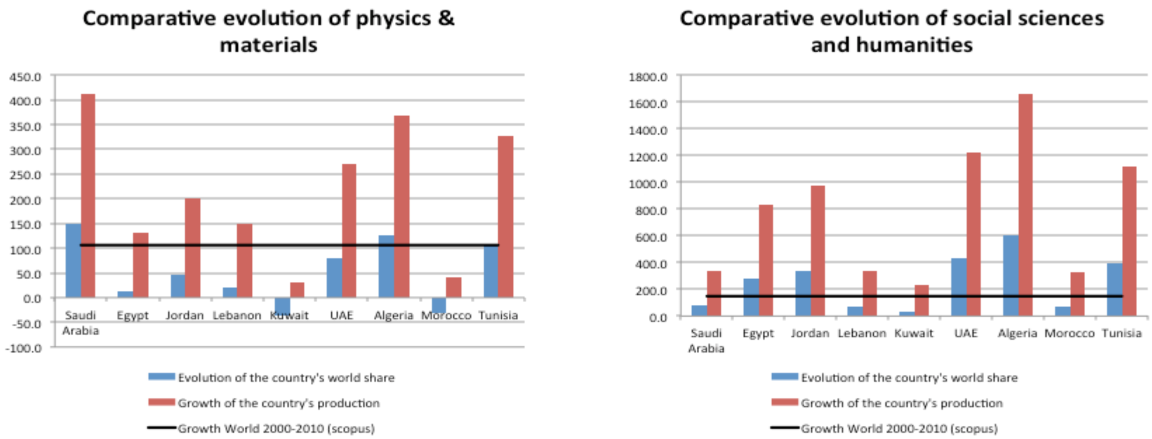



**Figure 8. Comparative evolution in Environmental sciences**

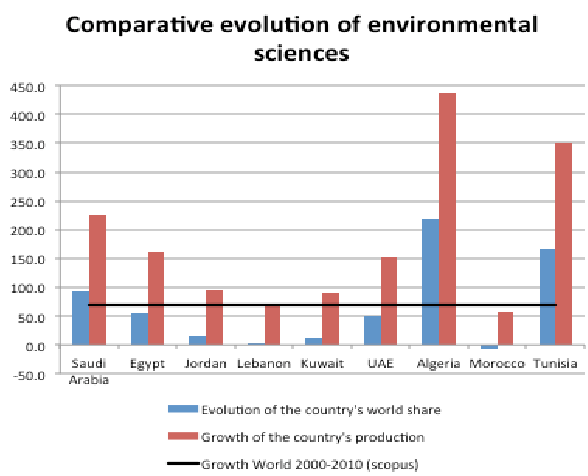
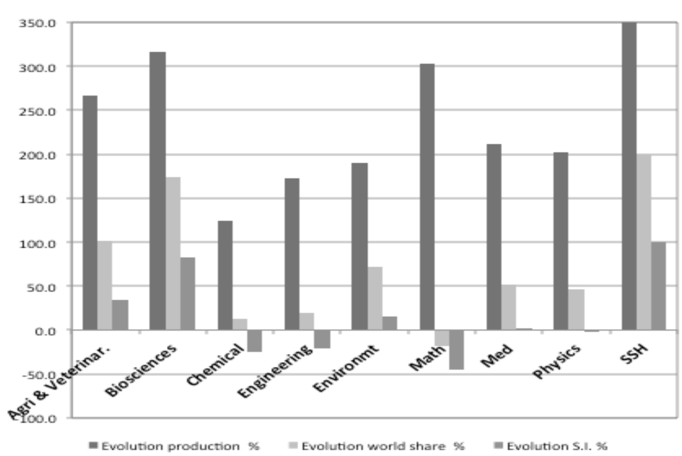
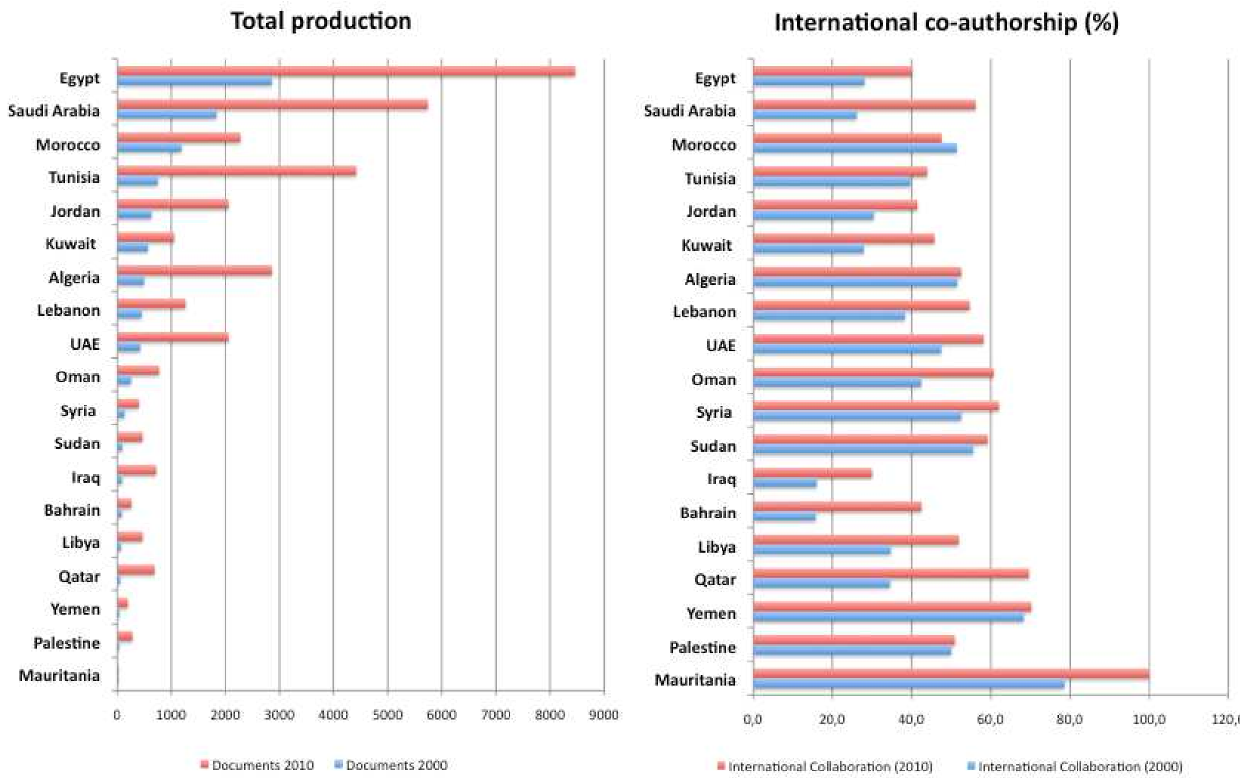



**Figure 9. Comparative evolution of main indicators per discipline**




*Note*: Scopus database as a whole has variations in number of journals included through time and this has an implication on the specialization indicators. This graphic is a reference of main changes per domain of the three indicators that we are using in this annex: total production, world share and specialization index.

**Figure 10. Total production and international co-authorship**



## BIBLIOGRAPHY


Aburdene, O. (2010). Creating Jobs in the Arab World through Innovation and a Culture of Venture Capital. Abana Conference. Salve Regina, Newport, August 6.

Adams, J., Gurney, K. et Marshall, S. (2007). *Patterns of international collaboration for the UK and leading partners (Summary report)*. London: A report commissioned by the UK Office of Science and Innovation. http://image.guardian.co.uk/sys-files/Education/documents/2007/07/13/OSICollaborationSummaryRepo.pdf

Akl, E.A. and others (2012). Willingness of Lebanese physicians in the United States to relocate to Lebanon. Human Resources for Health. Vol. 10, no. 15.

Al Maktoum Foundation and UNDP (2009). Arab Knowledge Report 2009: Towards Productive Intercommunication for Knowledge. Dubai.

Al-Athel, S. (2003). Science and Technology in Saudi Arabia: Proceedings of the 14th Conference of the Islamic World Academy of Sciences. Kuala Lumpur.

Amsden, A.H. (2001). The Rise of "the Rest": Challenges to the West from Late-Industrializing Economies. Oxford: Oxford University Press.

Arellano, H. A. and others (2012). 'Global connexity and circulation of knowledge. Aspects of Anthropology of Knowledge in Latin America', *Revue d'Anthropologie des Connaissances*, Vol. 7, no. 2, pp. 1-28.

Arvanitis, R. and Hanafi, S. (Forthcoming). Knowledge Production in the Arab World.

Arvanitis, R. (2003). 'Science and technology policy', in UNESCO, Knowledge for Sustainable Development – An Insight into the Encyclopedia of Life Support Systems (Volume 3), Paris: UNESCO Publishing, pp. 811-848.

Arvanitis, R. (2012). 'Euro-Med cooperation on research and innovation', Mediterranean Yearbook, Barcelona IEMED, pp. 259-68.

Arvanitis, R. and M'henni, H. (2010). 'Monitoring Research and Innovation Policies in the Mediterranean Region', Science Technology & Society, Vol. 15, no. 2, pp. 233-69.

Arvanitis, R. and Gaillard, J. (1992). '*Vers un renouveau des indicateurs de science pour les pays en développement*', in R. Arvanitis & J. Gaillard, eds., *Les indicateurs de science pour les pays en développement*/Science Indicators for Developing Countries, Paris: Editions de l'ORSTOM, pp. 9-36.

Barré, R. (2001). Policy making processes and evaluation tools: S&T indicators. In R. Arvanitis (Ed.), Science and Technology Policy (http://www.eolss.net/). Encyclopedia of Life Support Systems. Paris: UNESCO.

Barré, R. and others (2003). *Diasporas scientifiques. Comment les pays en développement peuvent-ils tirer parti de leurs chercheurs et de leurs ingénieurs*?, Paris: IRD Editions.

Bironneau, R. and others, eds. (2012). China Innovation Inc. *Des politiques industrielles aux entreprises innovantes*, Paris: Presses de Sciences Po.

Boekholt, P. and others, eds. (2009). Drivers of international collaboration in research: Final Report (Luxembourg: European Commission, DG Research, International Cooperation (EUR 24195).

Callon, M. and others, eds (1997). The strategic management of research and technology. The evaluation of research programmes, Paris: Economica.

Castellacci, F. and Natera, J. M. (2011). 'The dynamics of national innovation systems: A panel cointegration analysis of the coevolution between innovative capability and absorptive capacity'. MPRA Paper 31583, University Library of Munich.

Ciumasu, I. (2010). Turning brain drain into brain networking. Science and Public Policy, 37(2), 135-146.

CNRS (2011). Five Years Report (2007- 2011). Beirut.

Cooper, S. (1997). 'Plenitude and alienation: the subject of virtual reality', in Holmes, D. (ed.) Virtual Politics. Identity and Community in Cyberspace. London: Sage.

Danish Council for Research Policy. (2006). A Tool For Assessing Research Quality and Relevance. Available from: http://fivu.dk/en/publications/2006/a-tool-for-assessing-research-quality-and-relevance

Djeflat, A. (2011). 'Absorptive capacity and innovation demand as driving engines for emerging innovation systems (EIS): evidence from GCC and Maghreb countries' in 9th GLOBELICS International Conference, Buenos Aires.

Dreher, A. (2006). 'Does globalization affect growth? Evidence from a new index of globalization', Applied Economics, Vol. 38, No. 10, pp.1091–1110.

Dreher, A., Gaston, N. and Martens, P. (2008) Measuring Globalisation – Gauging its Consequences, Springer, New York.

D Dumont, J. and Lemaître, G. (2005). *Counting Immigrants and Expatriates: A New Perspective*. Paris: OECD., Direction du travail, de l'emploi et des affaires sociales, 24p.,http://www.oecd.org

Dumortier, B. (2008). '*La société de la connaissance dans une perspective arabe*', Maghreb-Machrek, *Printemps 2008* (195), pp. 13-20.

Economist Intelligence Unit (2011). 'A new era for R&D in the Middle East: List of Arab entrepreneurship initiatives'.

El Kenz, A. (1997). 'Prometheus and Hermes'. In T. Shinn and others, eds., Science and Technology in a Developing World (pp. 323-348). Dordrecht: Kluwer.

El Kenz, A. (2005). '*Les sciences sociales dans les pays arabes'*. Bondy, IRD – Projet ESTIME. http://www.estime.ird.fr/article50.html

El Kenz, A., and Waast, R. (1997). 'Sisyphus or the scientific communities in Algeria'. In J. Gaillard and others, eds. Scientific communities in the developing world (pp. 53-80). London & New Delhi: Sage.

Emirates Center for Studies and Strategic Research (2011). Educational Outcomes and Labor Market in the GCC (in Arabic). Abu Dhabi.

ESTIME (2007). 'Towards science and technology evaluation in the Mediterranean Countries (final report by R. Arvanitis)'. In Paris IRD Project no. INCO-CT-2004-510696.

Gabsi, F. and others (2008). 'Innovation determinants in emerging countries: an empirical study at the Tunisian firms level', International Journal of Technological Learning, Innovation and Development, 3(3), pp. 205-25.

Gaillard, A. and others (2013). 'Euro-Mediterranean science and technology collaborations: a questionnaire survey', in R. Rodriguez and R. Arvanitis, eds, Moving to the future in the Euro-Mediterranean Research and Innovation partnership: The experience of the MIRA project. Bari and Paris: Options Méditerranéennes, CHIEAM.

Gaillard, J. (2010). Measuring Research and Development in Developing Countries: Main Characteristics and Implications for the Frascati Manual. Science, Technology & Society, 15(1), 77-111.

Gaillard, J. and Gaillard, A. (2003). Can the scientific diaspora save African science? SciDev. Available from: http://www.scidev.net/en/opinions/can-the-scientific-diaspora-save-african-science.html.

Gaillard, J. and others (1997). 'Scientific communities in the developing world', in J. Gaillard and others, eds., Scientific communities in the developing world, London & New Delhi: Sage, pp. 11-49.

Gaillard, J. and others (2010). Mapping and drivers of Euro-LAC international cooperation in science & technology: A questionnaire survey. Bondy: IRD, UMR201.

Gaillard, J. et Arvanitis, R. (Eds.). (2013). Research collaborations between Europe and Latin America. Mapping and Understanding partnership). Paris: Editions des Archives Contemporaines.

Gérard, E. et al. (2008). *Mobilités étudiantes Sud-Nord: Trajectoires scolaires de marocains en France et insertion professionnelle au Maroc*. Paris: Publisud.

Ghattas, Kim (1999). "Expatriates on the Move Home, Sweet Home," (Report)<http://www.tokten.com/employ.htm>.

Glänzel, W. (2001). National characteristics in international scientific co-authorship relations. *Scientometrics, 51*, 69-115.

Godin, B. (2005). Measurement and statistics on Science and Technology: 1920 to the present. London & New York: Routledge.

Goudineau, Y. (1990). *Etre excellent sans être pur: potentiel technologique et pouvoir technocratique à Singapour*. *Cahier des Sciences Humaines, 26* (3), 379-405.

Hanafi, S. (2008). "Virtual and Real Returns". S. Hanafi (Ed.) *Crossing borders, shifting boundaries: Palestinian Dilemmas*. American University in Cairo Press.

Hanafi, S. (2010). "University Systems in the Arab East: Publish Globally and Perish Locally Vs. Publish Locally and Perish Globally". Current Sociology.Vol 59, no 3, pp. 291 - 309.

Hanafi, S. Rigas Arvanitis, Justine Baer (2013). "Internationalization of Science in Lebanon – The American University of Beirut – A Case Study". Michael Kuhn and Kazumi Okamoto (eds.). Spatial Social Thought: Local Knowledge in Global Science Encounters. IBIDEM, Stuttgart.

Hicks, D.M. and Katz, S.J. (1996). 'Where is science going?' in Science, Technology & Human Values, Vol. no. 214, pp. 379-406.

Inkster, I. (1991). *Science and technology in History. An approach to industrial development*. London: Macmillan.

Issam Fares Institute (2011). 'Public Policy and Research in the Arab World: Pre & Post Uprising. Report of the first meeting of the CAPRI (Consortium of Arab Policy Research Institutes)'. Beirut.

INSEAD & S. Duta (2012). The Global Innovation Index 2012. Stronger Innovation Linkages for Global Growth. Paris: INSEAD.

Intarakumnerd, P. and J. Vang (2006). 'Clusters and Innovation Systems in Asia', Science Technology & Society, 11(1), pp. 1-7.

Kabbanji, J. (2011). 'Why have the Tunisian and Egyptian revolutions surprised us?' in Idafat: Arab Journal of Sociology, 14, 9-31. [in Arabic].

Kabbanji, J. (2012). '*Heures et malheurs du système universitaire libanais à l'heure de l'homogénéisation et de la marchandisation de l'enseignement supérieur*' in *Revue des Mondes Musulmans et de la Méditerranée*, June (131), pp. 127-45.

Kassir, S. (2004). *Considérations sur le malheur arabe*, Paris: Actes Sud.

Khalaf, S. (2012). Protestant Missionaries in the Levant: Ungodly Puritans, 1820-1860. London: Routledge.

Khelfaoui, H. (2004). 'Scientific research in Algeria: Institutionalisation versus professionalisation', Science, Technology & Society, 9(1), pp. 75-101.

Khelfaoui, H. (2006). '*La recherche scientifique en Algérie, otage de la médiation politique*', in E. Gérard, ed, Savoirs, insertion et globalisation. Vu du Maghreb, Paris: Publisud, pp. 189-216.

Khelfaoui, H. (2000). *Les ingénieurs dans le système éducatif: L'aventure des instituts technologiques algériens*. Paris: Publisud.

Khelfaoui, H., ed. (2006). *L'intégration de la science au développement*. Expériencesmaghrébines, Paris: ADEES/Publisud.

Khodr, H. (2011). The dynamics of policy innovation and diffusion in the Gulf Cooperation Council: A case study of three specialized cities. Working Paper, Institute Issam Fares, AUB, Beirut. On-line http://www.aub.edu.lb/ifi/

King Abdulaziz City for Science and Technology (2012). Information about KACST. Available from: http://www.kacst.edu.sa/en/about/Pages/default.aspx

Kleiche, M. and Waast, R. (2008). *Le Maroc Scientifique*. Paris: Publisud.

Lablaoui, H. (2010). «Return of Algerian Qualified Expatriates: End of an Experience in Diapora or A new Cycle in International Mobility?». *Idafat: the Arab Journal of Sociology*. No 10, pp. 75-97.

Lepori, B. and others, (2008). 'New perspectives and challenges for the design and production of S&T indicators', Research Evaluation, 17(1), pp. 33-44.

Leresche, J. and others, eds. (2009). *Recherche et enseignement supérieur face à l'internationalisation*. France, Suisse et Union européenne, Lausanne: Presses polytechniques et universitaires romandes.

Lord, K. (2008). 'A New Millennium of Knowledge? The Arab Human Development Report on Building a Knowledge Society, Five Years On', Washington, DC: Saban Center at Brookings Institution.

Losego, P. Arvanitis, R. (2008). 'Science in non-hegemonic countries', Revue d'Anthropologie des Connaissances, 2(3), pp.343-50.

M'henni, H. and Arvanitis, R. (2012). '*La résilience des systèmes d'innovation en période de transition: la Tunisie après le 14 Janvier 2011*', Revue Tiers Monde, Octobre-Décembre 2012(212), pp. 57-81.

Mattsson, P., Laget, P., Nilsson, A. et Sundberg, C.-J. (2008). Intra-EU vs. extra-EUscientificco-publication patterns in EU. *Scientometrics, 75* (3), 555-574.

MEDIBTIKAR (2010). EuroMed Innovation and Technology Programme (MEDIBTIKAR). EU-funded Regional and Communication Project on the European and Mediterranean Partnership (EUROMED). p. 78.

Mermier, F. (2005). *Le livre et la ville: Beyrouth et l'édition arabe*, Arles: Sindbad/Actes Sud.

Meyer, Jean-Baptiste et al.(1997). "Turning Brain Drain into Brain Gain: The Colombian Experience of the Diaspora Option", *Science Technology and Society*, vol. 2, no. 2.

MIRA Observatory (2011a). Assessment of international scientific cooperation in the Mediterranean region: An international challenge ahead. Available from: www.miraproject.eu

Monastersky, R. (2005). The Number That's Devouring Science. *The Chronicle of Higher Education, 52* (8), A12. http://chronicle.com/free/v52/i08/08a01201.htm

Morgan, M. and O'Gorman, P. (2011). 'Enhancing the Employability Skills of Undergraduate Engineering Students'in Aung, W., ed. Innovations 2011: World Innovations in Engineering Education and Research. Potomac: iNEER pp. 239-248.

Mouton, J. and Waast, R. (2009). 'Comparative Study on National Research Systems: Findings and Lessons' in V.L. Meek and others, eds. Higher Education, Research and Innovation: Changing Dynamics. Paris: UNESCO, pp. 147-69.

Mrad, F. (2011). RDI for Knowledge Economy. Beirut: ESCWA.

M-Oukil, S. (2009). Enhancing innovation and entrepreneurship for growth and competitiveness of Arab business organizations. Third Scientific Forum in Jordan, April.

Nour, S. S. (2005). 'Science and technology development indicators in the Arab Region' in Science Technology and Society 10(2), pp. 249-275.

Oliveira, J.B.A. (1984). *Ilhas de competência: carreirascientíficas no Brasil*. São Paulo: EditoraMelhoramentos.

Oukil, M-S. (2011). A development perspective of technology-based entrepreneurship in the Middle East and North Africa. Annals of Innovation and Entrepreneurship, Vol. 2.

Pasimeni, P. (2011). 'The Europe 2020 Index' in Social Indicators Research, Springer, no. 110 pp. 613-635.

Pasimeni, P. (2012). 'Measuring Europe 2020: a new tool to assess the strategy' in International Journal of Innovation and Regional Development, Vol. 4, no. 5, pp. 365-83.

Pasimeni, P. and others (2007). 'Towards a Euro-Mediterranean Innovation Space: Some lessons and policy queries'. The CONCORD seminar ITPS, Seville, October.

Reiffers, J. & J. Aubert (2002). *Le développement des économies fondées sur la connaissance dans la région Moyen-Orient et Afrique du Nord: facteurs clés*, Marseille: World Bank.

Romani, V. (2011). *Enseignement Supérieur, Pouvoir et Mondialisation dans le monde arabe. Revue des mondes musulmans et de la Méditerranée*. Special issue.

Rosenberg, N. (1982). *Inside the blackbox: Technology and economics*. Cambridge: Cambridge University Press.

Rossi, P. L. (2010). Scientific Production in Arab Countries: A Bibliometric Perspective. Science, Technology & Society, 15(2), pp. 339-370.

Rossi, P. L. (2009). Bibliometric study of Mediterranean Countries. ESTIME Project. Available from: http://www.estime.ird.fr

Roussillon, A. (2002). '*Sociologie et identité en Égypte et au Maroc: le travail de deuil de la colonisation*' in Revue d'Histoire des Sciences Humaines, Vol. 2, no. 7, pp. 193-221.

Saint Laurent, B. (2005). *Innovation, pôles technologiques et attraction d'investissement en Méditerranée*, Marseille Notes & Document no. 9: ANIMA-AFII.

Salih, Nabil 'Abd al-Majid. 2008. Science and Technology Indicators in the Arab Countries 2006.

Sayegh, M. and Badr, K. (2012). 'Reversing the brain drain: a Lebanese model' in Nature Middle East, 4 October 2012. Available from: http://www.nature.com/nmiddleeast/2012/121004/full/nmiddleeast.2012.143.html

Schmoch, U. et Schubert, T. (2008). Are international co-publications an indicator for quality of scientific research? *Scientometrics, 74* (3), 361-377.

Schwab, K. and Sala-i-Martín, X., eds. (2012). The Global Competitiveness Report 2012-2013. Geneva: World Economic Forum.

Schwartzman, S. (1991). A Space for Science: The Development of the Scientific Community in Brazil. University of Pennsylvania Press.

Stehr, N. (1994). Knowledge Societies. London: Sage.

UNCTAD. (2012). World Investment Report 2012: Towards a New Generation of Investment Policies. Available from: http://unctad.org/en/Pages/DIAE/World%20Investment%20Report/WIR2012_WebFlyer.aspx

UNDP (2000). *A Four-year Brain Grain* (Jerusalem: UNDP, pp. 1-2. (UNDP draft)

UNDP (2005). Arab Human Development Report 2004: Towards Freedom in the Arab World. Amman: UNDP Regional Bureau for Arab States.

UNESCO. (2009). Proceedings of the Arab Regional Conference on Higher Education. Towards an Arab Higher Education Space: International Challenges and Social Responsibilities. Cairo.

UNESCO. (2010a). Measuring R&D: Challenges Faced by Developing Countries. Available from: http://www.uis.unesco.org/Library/Documents/tech%205-eng.pdf

UNESCO. (2010b). Science Report: The Current Status of Science Around the World. Available from: http://www.unesco.org/new/en/natural-sciences/science-technology/prospective-studies/unesco-science-report/unesco-science-report-2010/

UNESCO. (2011). EFA Global Monitoring Report: The hidden crisis: Armed conflict and education. Available from: http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/efareport/reports/2011-conflict/

Valenti, G. and others, eds. (2008). *Instituciones, sociedad del conocimiento y mundo del trabajo*, Mexico: FLACSO Mexico, Plaza y Valdés Editores.

Vessuri, H.M.C. (1994). 'The institutionalization process', in J. Salomon and others, eds., The uncertain quest: science, technology, and development. Paris: UNU Press, pp. 177-212.

Waast, R. (2006). '*Savoir et société: un nouveau pacte à sceller*' in E. Gérard, ed, Savoirs, insertion et globalisation: vu du Maghreb, Paris: Publisud, pp. 373-403.

Waast, R. and Rossi, P. L. (2009). A scoreboard and beyond: The experience of ESTIME for Morocco and other Mediterranean countries. IRD MIRA indicators Workshop, 16-17 March, Bondy. http://www.estime.ird.fr/

Waast, R., and Kleiche-Dray, M. (Eds.) (2009). Evaluating of a national research system: Morocco. Luxembourg: European Commission.

Waast, R. and others (2010). 'What do social sciences in North African countries focus on?', World Social Science Report, Paris: UNESCO, pp. 176-80.

Wagner, C. (2008). The New Invisible College: Science for Development. Washington D.C: Brookings Institute Press.

Wahishi, Kh. (2010). Introduction in Idafat: the Arab Journal of Sociology. No 10. pp. 7-12.

Wight, D. (2008). "Most of our social scientists are not institution-based, they are for hire: Research consultancies and social science capacity for health research in East Africa". Social Science and Medicine no. 66, pp. 110-116.

Willso, Michele (1997). "Community in the Abstract: A Political and Ethical Dilemma?," in: David Holmes, ed., *Virtual Politics: Identity and Community in Cyberspace* (London; Thousand Oaks, CA: Sage Publications), p. 158.

World Bank (1999). Knowledge for development. World development report 1998-1999, Washington D.C.

World Bank (2012). Knowledge Assessment Methodology. Knowledge Economy Index 2012 Rankings. Washington D.C. http://go.worldbank.org/JGAO5XE940

World Economic Forum and OECD. (2011). Arab World Competitiveness Report 2011-2012.

Yilmaz, F. (2012). 'Right-wing hegemony and immigration: How the populist far-right achieved hegemony through the immigration debate in Europe' in Current Sociology, Vol. 60, no. 3, pp. 368-81.

Zahlan, A.B. (2012). Science, Development, and Sovereignty in the Arab World.New York: Palgrave Macmillan.