Applying Scientific Research To the local Economy in ESCWA Countries

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1. Introduction

Research and analysis on knowledge production and innovation in the Arab World has grown exponentially in recent years, as quickly as scientific investigations themselves. Research has grown as never before, not only in those countries that had invested in science and technology after their independence, but also from "newcomers" in science, particularly from the Gulf countries.

There has been, closely linked to this growth, a growing consciousness about the importance of knowledge in society. The excellent recent study publish by Antoine Zahlan, a long-time observer of scientific development in the Middle East, titled ' *Science, Development, and Sovereignty in the Arab World'* underlines this general move towards not only more scientific activities but also presents a reflection on how and why scientific research should be developed. Zahlan's study, as with the many official documents that one can now find under the auspices of large organisations, either regional or international, advocates for more research and more innovation. Usually this is based on a diagnosis of the low intensity of research, and is accompanied by some wishful thinking that science and/or innovation will, at the end, become some priority for the Arab States.

The present report belongs to this same general thread of thinking, since its authors are convinced that there is room for improvement of research and innovation activities. This report also shares a national perspective rather than a regional outlook, in which the efforts of each country are examined individually. But we do believe that the dynamic of research and innovation is not only related to national policies and national frontiers. Rather it is a dynamic based upon the social actors that are directly or indirectly involved in the development of scientific activities: individual researchers, research groups, research institutions, universities and high educational institutions, 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 plain opposition.

Perhaps prematurely, Arab countries have wanted to be called 'knowledge societies' (See the first chapter of the Arab Knowledge Report 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 after the World Bank report of 1999 that became a policy objective along with, and sometimes in contradiction with the building of national innovation systems. All these concepts were drafted for developed economies that enjoy a dense network of research institutions, a high degree of investment in R&D, either in public or private institutions, and a strong infrastructure, known, since the rise of the digital age, as 'knowledge infrastructures'. Curiously enough, the knowledge economy concept was drafted by the World Bank report (1999) mainly based on a comparative observation of the tendencies in Asia and Latin America, and directed by an official of the Bank based in Mexico City. Probably among the very first authors to write about the 'knowledge society' is Nico Stehr (1994).[1] He addresses the consequences of the remarkable growth of science and technology on our modern societies undergoing a fundamental shift: science became an immediately productive force; science no more is 'cultural' product but enters a basic ingredient of any sustainable and long-term economic strategy. The closeness of science and technology that research has uncovered is here to remain and will run deeply in social and political decisions. As scholars from all over the world have shown, a new set of institutional capabilities is deployed everywhere.[2] Apart from glorifying the name of 'knowledge' there has been little reflection on these changes in the Arab World.[3]

Simultaneously, since the end of the nineties, emerging economies became the concept of the day, and with the new century the World appears as a multipolar scene where 'knowledge', evidently, plays many different and very central roles. In the process, the 'Third World' or 'developing countries' seemed to have disappeared from the radar within the new knowledge economy. A new concept needed to be given to what Alice Amsden rightfully called 'the Rest' [of the World]. If 'developing' economies is no more right word, then what is it? Is it that the modes of producing, using and diffusing knowledge have changed so much that development itself is an obsolete concept? Are we all living in a 'flat world' with no borders and where power structures disappeared? Whatever the position one defends concerning globalization, whether beneficial or harmful, there is no doubt that science and technology is tightly woven in its orientations and knowledge has become a basic component, as stressed by the Arab Knowledge Report (2009). Multipolarity, indeed, does not mean the disappearance of hegemony: it is, on the contrary, the clear indication that hegemony in research and innovation will be a multi-player game, much more offensive than the divided World of Centers and Peripheries. Two French sociologists (Losego and Arvanitis 2008) have proposed to call those countries that belong neither to the older 'central' countries nor to the new emerging economies, "non-hegemonic countries".

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 case of the USA, the European Union and some rare South-East Asian countries. Things are probably different for innovation than research, since not all innovation is research-based, and since innovation can be more multi-faceted

[1] Part of his writing on the topic was made in Mexico also.

[2] See the collection gathered by the program on knowledge society of the Latin American Faculty of Social Sciences (FLACSO) Valenti, G., M. Casalet & D. Avaro, eds (2008). *Instituciones, sociedad del conocimiento y mundo del trabajo*, Mexico: FLACSO Mexico, Plaza y Valdés Editores.

[3] 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, the 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 his Chapter 10, p.157-175. On Emirates knowledge society read a special issue of the scholarly journal Maghreb-Machrek edited by Dumortier, B. (2008), 'La société de la connaissance dans une perspective arabe', Maghreb-Machrek, Printemps 2008(195).

than research. Nonetheless, non-hegemonic countries have usually been adopting an incremental development model, based on technological catching-up. The whole experience of South-East Asia is precisely the story of catching-up, learning and adopting technologies that become central tools of economic development.

Strengthening knowledge production, use and dissemination

This report would like to investigate these possibilities and opportunities for an increased research activity, for increased innovation, without taking it for granted that these increases will come one day by simple ‘vegetative’ growth of the academic sector or just by adding up more entrepreneurial activities.

In effect, as Mouton and Waast (2009) pointed out in detailed country studies among middle-sized economies, one can easily distinguish countries that have put decided emphasis on research, from a set of countries that have not been so keen to invest in research and innovation. The reasons are not to be found in the clear view of the former as opposed to the lack of decision of the latter: this kind of argument does not make sense at the level of a country, where trends results from multiple actors and conditions. This categorization, as any other, is always the result of history –among other things the role of the state, the relation of the state to its scientists and to the use of knowledge in the state apparatus, the development strategies (and how much national development becomes an objective), and trust in science (which relates also to how elites see science).

On the front of *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 can ever doubt about the entrepreneurial abilities in Arab societies. Innovation is a complex process that always results from a combination of investments, organization and technology; to make things more difficult, individual success of a company does not necessarily translate directly into economic indicators for all the economy. This last characteristic makes the argument in favour for science policy always complex: effort accumulates over time, innovation depends upon previous choices and is “path-dependent”, meaning that today’s success is based on yesterday’s effort. The type of research you do today will determine the kind of innovations related to research you will reap tomorrow.

It is important to emphasize that for research, as for innovation, the growth of activities follows a cumulative path. This path-dependency is particularly important because new research and innovation activities will always depend upon former investments, and former experiences. And, this is true both for research-driven activities as well as for innovation and technology in general. All technologies are constructed on prior experience, and progressive technological learning builds out of accumulated practices. Moreover, the form innovation takes tomorrow is very much depending upon the kind of technological research you engage today. A great part of the resulting technologies will depend upon your connections and networks you will have developed; in turn, these will create the circuits where information and resources needed for innovation will circulate. And in the same way you will have progressively build the infrastructures that are needed for innovation. In turn, these create the so-called “cultural” conditions for innovation.

All studies that have flourished in the last years concerning the Arab World have some degree of difficulty in identifying specific causes to the low catching-up and to this under-investment in knowledge. This hinders the constructive contributions of local researchers and scientists to local and regional economies. It goes back to the *scale of analysis* which has been usually the national level, which is, as mentioned above, not easy to manage.

There are historical reasons for this choice. Since the Second World War, science has been thought of as a *national endeavour*, and as an expression of national sovereignty. This has been expressed by building institutions that have a national scope of activity and are closely related to areas of state power. Academic disciplines, areas of technological investments, domains of interests and objects of research were seen through the national lens. The view of 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 of drawing national priorities. As globalization becomes an economic and political norm, the national orientation has been strategically under threat. Areas such as nanotechnology or biotechnology developed in emerging countries despite low investments in other areas, become visible at a global level, and disciplines tend to be defined internationally. This global view of research has been, paradoxically, constructed at the same time when *national innovation systems* were proposed as the objective of innovation policies. Thus *global research and locally-based innovation have become the norm.*

Strengthening research

When tensions arise concerning products that are closely related to science, technology and innovation, countries are involved not as one-state actors in a multilateral negociation but inside fragmented controversies between globally reaching actors. This has been clearly shown in public health issues (e.g. access to anti-retroviral medicines), intellectual property issues in global technologies, use and management of local knowledge systems (e.g. in natural products with pharmaceutical action) or biodiversity resources. Fundamental issues including risk, food security, energy provision and use, desertification, contamination of the environment, all need local solutions that can be constructed by a close interaction with world wide accessible knowledge. A large variety of actors are involved in practically all themes and research has become a mode of access to knowledge. Research is also part of negotiations in world arenas (the most emblematic being the WTO) and other international fora where standards defining acceptance, health and security codes and regulations, trade regulations, are based upon research activities. The ticket to pay in order to be included in the very closed club of those proposing norms and regulations at the global level is research.

Resolving the riddle of under-investment in research and innovation in the Arab World partly relates to strategic choices in investment, research choices, strategic decisions concerning areas such as solar energy, desertification, water resources, use of non-conventional sources of energy, uses of nanotechnology in low tech environments, orphan and geographically-specific diseases, as well as management of local institutional forces, decision-making systems. ‘Technical’ (or scientific and engineering) choices reflect, *in fine,* political choices and no technocratic decision will help choosing one among others as being more necessary of more important. The agenda for science and innovation is always a political agenda.[4] It depends upon how *knowledge is created, used, and disseminated in the region*, a process that is still not well known or studied in the Arab world.

Moreover, the effort to implement an active research structure recommends the development of a common multilateral strategy involving centers in different countries, a topic discussed

[4] A good overview of issues for future research as seen from the eyes of Europeans can be drawn from the topics of the Barcelona Conference that was organized by the European Commission. 2-3 April 2012.

during the Arab summit in 2010. But this is also a political choices: until now very few countries have been willing to share their resources, even within the region. The various new institutions mentioned by the Arab Knowledge Report have been national endeavors with little multilateral cooperation. Scientific collaboration is the very heart of the scientific activity and multilateral cooperation in policy-making would be a necessary step. For the time being we seem very far from there.

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 centers of the region; it is necessary to examine how innovation activities take place. The latter are even less understood than the public research activities merely because too few scholars study what effectively happens inside enterprises. 'Academic life' should be understood in a broader sense than 'university' life and population. It includes teaching personnel in universities and higher education schools, researchers from public research institutes, and engineers in public or private institutes that work in technology development. The issue of connecting science to society, applying scientific and engineering knowledge to the economy is not reducible to the issue of commercializing nor only the creation of the right business environment. It is a matter of weaving the multiple forms of links between production and use of knowledge.

Furthermore, the study aims at presenting a vision on the future positive role that scientific research, particularly applied research, can play in the socio-economic development of the ESCWA region. Particularly in enhancing the competitiveness of the productive and services sectors, and how institutions and governments of the region can cooperate to reach that goal.

Structure of the report

This report examines the findings and lessons of a comprehensive review of national research systems in the Arab World. It tackles some issues that might not be consensual but aims at creating a discussion that is now very much needed:

1. Indicators showing the macro performance and the governance of the research systems in the Arab region. The report will also consider the concerning research funding.

2. The knowledge production and scientific collaborations through publications of a few Arab countries.

3. A short review of the innovation systems and policies in favour of innovation.

4. Some observations on the special role of universities and various issues related to human capacity and scientific capital including the difficult issue of brain-drain.

Before discussing the main findings, a brief note on the overall aims of the study as well as key methodologies employed is in order.

Methodology of this report

The report is a meta-review of existing country studies in the Arab world. A meta-review (or systematic review) is a study that has both a descriptive and evaluative aims.

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

(2) To examine statistics that are available on the state of science and technology in the Arab World. There is an expressed need of reliable indicators and 'evidence-based' policy recommendations. We report on the type of indicators that we have been able to gather. Next section is examining this question of the data in the region.

(3) To produce a summary "map" of the main themes that seem the most important ones to our view. Without being exhaustive we also wanted to use this opportunity in order to have an overview of the literature. This scholarly effort seemed important since today the literature on the topic is growing and getting more difficult to grasp.

2. Indicators and data in the Arab science system

Before entering into the description of the research system and of factors affecting the scientific dynamic, we explored the usual indicators available to public scrutiny. The sources here are not so numerous. Most of the statistical information has been compiled by UNESCO[5], and by the Organisation for Economic Co-operation and Development (OECD)[6] for member countries of the Organization. COMSTECH[7] countries have gathered data also and there is no common definitions for manpower, or financial indicators and statistics. All these organizations rely on reporting by public authorities. It is understandable that national authorities provide data at the national level. But in most countries, the State has not given special interest to science and technology as part of their statistical administration.

There are many drawbacks in the information, as has been repeatedly mentioned in various projects and institutions (ESTIME, MEDIBTIKAR, UNESCO, ALECSO, Zahlan's recent book)[8]. Data on research and innovation in the Arab world is not sufficiently well documented.

Absence of indicators

After so many years of recommendations made by all possible international organizations, there are still no reliable data on *inputs*, that is data gathered following the internationally accepted standards (included in the so-called "Frascati Manual"). It should be underlined that these statistical standards have been the product of a professionalization of statistical data on

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

[6] See OECD Directorate of Science, technology and innovation. www.oecd.org/sti/. The countries of OECD are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israël, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

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

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

science and technology, and even if they have their own drawbacks (Godin, 2005), they were designed to respond to the need of a global view of the sector. In particular, R&D statistics have been closely related to the need to evaluate the competitive position of large OECD countries. To do this, a statistical infrastructure has been created. Most Arab countries, on the contrary, have been away from these statistical debates related to the OECD countries. They have not had incentives to promote statistics of the same nature and usually this need is expressed by some international organization that presses them to produce uniform data. In brief, most Arab countries have had the same debate, their main interest being other than the OECD countries on competitiveness. Thus, no reliable statistics exist on research and innovation and no statistical infrastructure or institution has been designed to produce said indicators. This can be particularly problematic when establishing international comparisons. No need to underline that this is not a situation experienced only by Arab countries. Outside Europe, USA and Canada, Latin America has developed a good network of observatories called RICYT. The network has been supported regularly by UNESCO. No such network exists in Asia or in Africa but some organizations like Globelics[9] have promoted linkages between units working for policy-making bodies in technology, innovation and economic development. In the Mediterranean region, because of its strategic interest for the EU, a number of such networks have been promoted.[10] As we have mentioned in the introduction, following the Mouton & Waast study (2009), we can easily identify those countries with a set of relatively well design indicators : they are the ones that somehow, politically, showed an interest for science and technology at the national level.

Experiences of Observatories of science and technology

It would be unfair to say that no effort has been made for a reliable statistical basis and the creation of indicators in science and technology in the Arab World. The ESTIME project, funded by the EU has made an attempt for this, and the MIRA project, which has followed (2007-2012) has included the creation of such an observatory as part of its objectives. MIRA produced, after three workshops, a “White Paper” on this issue in order to underline the guidelines for such an endeavour. [11] Experience so far shows that the indicators units have to manage a variety of data (Barré 2001): 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. As far as we know, no entity has been created so far in the Arab world able to manage this kind of data.

Some countries have actively sought to create observatories; this has been the case of Tunisia, Lebanon, and Jordan. Their fate is still fragile. To our knowledge the Jordan project was halted. Tunisia dismantled its Observatory under the Ben Ali administration and for political reasons related to the policy orientation of the last Ministry of research of the Ben Ali era. The project has not really been revived, although formally the Observatory has been maintained as an office inside the Ministry. Lebanon has underlined the need to create an observatory in its Science and technology plan; the National Council for scientific research (CNRS) has launched the LORDI after that (Lebanese Observatory on Research,

[9] www.globelics.org

[10] 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 mentionned in some detail (to be published as special of the journal “*Options méditerranéennes*” published by CIHEAM, january 2013.

[11] www.miraproject.eu (search ‘observatory’ to get the relevant documents).

Development and Innovation), and with a first feasibility study funded by ESCWA. Its first initiatives are underway (innovation survey, S&T survey, set-up of indicators). Morocco has had an intense discussion since many years on the topic, and in the framework of a EU-Morocco joint "Twinning" project, the issue has been again raised with the Ministry in charge of research, the Academy of Science and the Moroccan institute for scientific information (IMIST). In the Middle East, at regional level, ESCWA has repeatedly proposed to include such an observatory on indicators as a support to policy-making. The newly created ESCWA Technology Center, based in Amman, includes an indicators unit that is still to be created.

Looking at the successful experiences of countries that developed an indicator unit in S&T, we find in all cases that the unit is usually backed-up by some academic team, or at least a policy-making 'think tank' that is composed by academics out of various social sciences as well as from natural an exact sciences. There is a 'virtuous' interaction between the fulfilment of policy objectives, the provision of adequate information, processed in an intelligent way and responsive to policy needs, and the production of 'basic" knowledge on the science and technology community, the relations of scientific areas and productive and service sectors in the society. What Latin America can teach us, in this regard is precisely this close connection of the academic work and the development of a policy on science and technology (Arellano et alii 2012). Something similar happened in Asia around the concept of regional innovation systems: indicators appeared relating to the development of regional clusters of technology and the need to understand this sprouting economic phenomenon that the governments were willing to promote. Thus in Malaysia, Thailand, and China, indicators appeared related to some office in charge of policy-making.[12] Indicators appear as the by-product of an intellectual effort to understand the domain of science and technology.

Types of sources and indicators

In the absence of reliable and robust indicators, two strategies are usually developed: the use of opinion surveys or polls; and, the use of rankings based on composite indicators.

Policy makers and (more importantly) investors prefer to rely on indicators that are drawn out of opinion polls. Usually this method, used for example by the Competitiveness report, rely on a survey of persons considered "knowledgeable informants," that is persons who by their professional position have a good view of the research and innovation activities. Professors, academics but also entrepreneurs and policy-makers are thus asked to grade a series of variables or dimensions that compose the research and innovation dimensions. This somehow mitigates the risks of false data; nonetheless, the view of the field is reduced by the mean of opinions expressed by this collection of informed persons. Since nobody can claim to have a global view of the sector out of his/her own experience, this is considered as an acceptable way to show the state-of-play.

It would be too difficult to enter into the reasons why a 'mean' of opinions is not the same as a general point of view; suffice to say that who are the actors answering such a survey is as important as the points of view they express. Moreover, the questions and dimensions rated by the persons give room to some interpretation; it might well be that some opinions do not address the issues within the same interpretative frame as the one used by the authors of the

[12] For South-Eas Asia see the special issue of the Journal Science, Technology & 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).

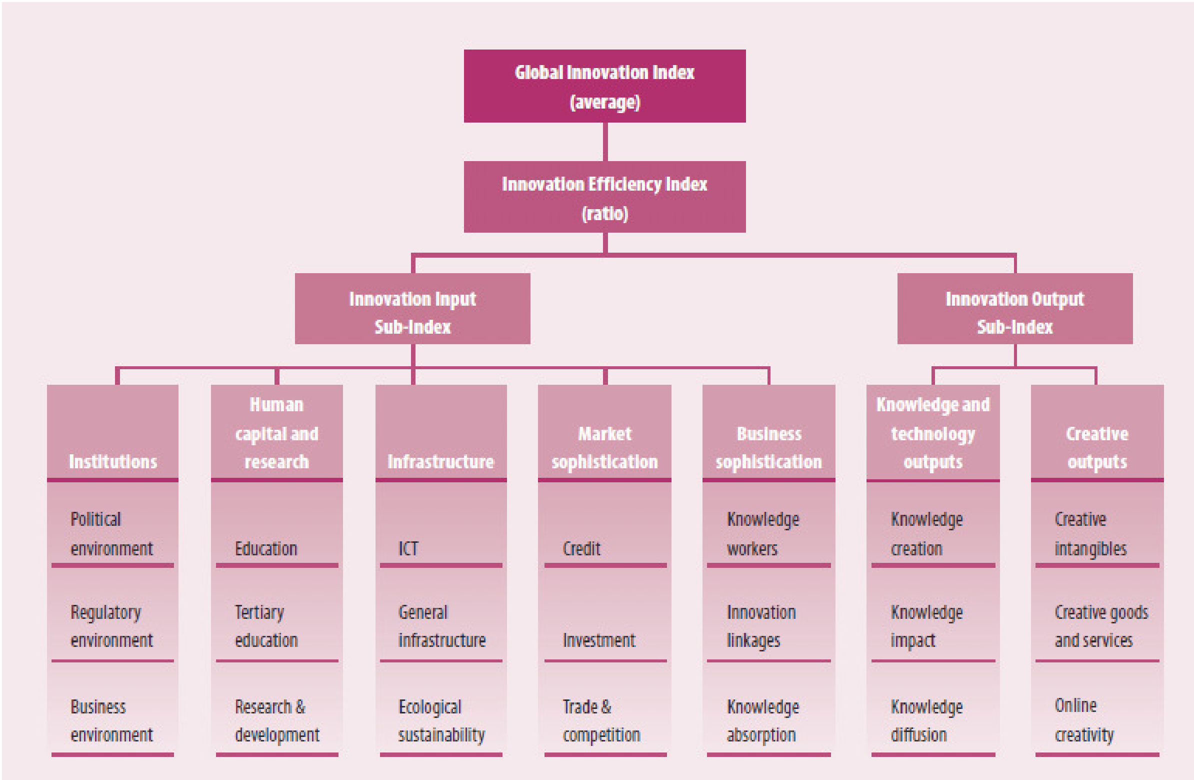


Figure 1. Global Innovation Index framework

report using these responses.[13] Finally, the surveying and use of statistical mean as reflection of opinions on the social and economic situation expresses a demise of the capacity to modify or influence these opinions.

A second possibility, which has been used for example by the World Bank, is to rely on more general indicators and transform the variables either into rankings or into marks, which also permits the creation of somewhat more robust although less detailed indicators. The rationale behind this kind of complex indicators is that the design of a multidimensional indicator would reflect the various factors that make-up a complex notion as "competitivity", innovation and so on. The World Bank in its methodology uses four 'pillars' that are a set of indicators.[14] These are "economic incentives and institutional regime, innovation and technological adoption, education and training, and infrastructure in information and communications technologies. A similar methodology has been proposed to measure 'Europe 2020' strategy for smart, sustainable and inclusive growth in the European Union (EU) also called 'Lisbon Strategy' of the EU 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 EU in June 2010 (Pasimeni 2011 & 2012). The complexity is reduced to 8 indicators. Another similar methodology is proposed by Dreher (2006 & 2008) in order to measure

[13] Socio-economic literature is abundant on these matters. A recent case of reflection can be found in the studies published by Leresche, J.-P., Larédo, P., & Weber, K. (Eds.). (2009). Recherche et enseignement supérieur face à l'internationalisation. France, Suisse et Union européenne. Lausanne: Presses polytechniques et universitaires romandes.

[14] "Knowledge Assessment Methodology". See web page: http://go.worldbank.org/JGAO5XE940

'globalization' in three dimensions: social, political and economic. The best known such index is Global Competitiveness Index that comprises 12 pillars, in which 133 economies are ranked. Technological readiness and Innovation are two of these pillars. Finally, INSEAD business school in Paris has developed a Global Innovation Index (INSEAD 2012) covering 141 countries. This Global Innovation Index 2012 (GII) relies upon a series of indicators that are grouped in five input pillars that enable innovative activities: (1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication, and (5) Business sophistication. Two output pillars capture actual evidence of innovation outputs: (6) Knowledge and technology outputs and (7) Creative outputs (Figure 1). The GII is quite consistent and is used in our own analysis.

Bibliometric indicators and impact

Usually two sorts of reliable sources of "output" are used: publications and patents. But both these depend upon the existence of databases which, themselves depend upon the social and economic system. In the case of scientific publications, it is the complex world of publishing that combines the scientists and the publishers, sharing scientific and economic considerations. This was labelled an "invisible college" and the editors of journal were "gate-keepers". Today this general social organization is much more complex and the hierarchy of journals, disciplines, institutions and countries is more difficult to disentangle. Part of the debate on the validity of the "impact factor" stems out of this discussion: it is because the structuring of the scientific community gets so diverse that no specific discipline nor institution can waive the banner of the winner. As far as patenting is concerned, it is the economic and policy system that are the main drivers. Japan, for instance, is a strong patenting country in part because the patenting strategy of firms in Japan is to register many patents around one product rather than one patent covering most aspects of the same artefact. Complex strategies are elaborated that take into account the cost of patenting and expanding patent protection to other countries but also the dissemination of the information: patenting is not only a legal tool; it is also a publication and as such discloses the information. Both forms of publication, in academic journals and in patents, are not 'objective' indicators: they depend upon strategies and social organization. Thus publications and patents do not simply reflect performance (nor impact); they also show acceptance of the outputs by the specific social system. They are part of this 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 containing citation exist; they are produced by two major publishing entities (Thomson produces the Web of Science and Elsevier the Scopus database). They are a commercial activity as much as a source of information. These are not the only sources[15], but these two databases share the aim of being multidisciplinary, independent and provide citation data. It should be also noted that new methods have been proposed to do less evaluative bibliometrics and engage in analytical and mapping analysis (Lepori, Barré et al. 2008). Relational analysis, based either on words or citations, are complex and a whole new field is emerging that can be mobilized also for the Arab World. We can only recommend to train the necessary information engineers and give them stable appointments if such tools are to be used.

Another issue related to indicators, is the measurement of impact, stricto sensu, and is not related to citations (see about Impact factor in the bibliometrics section, page 44). As the

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

recent report for the EU mentions (MIRA White Paper 2011), the impact of scientific research can better be measured when it is done at the level of a project, but certainly not for a discipline as a whole and even less for a country as a whole.

Impact of research is a complex concept and relates not only to the disciplines but also to the structuring of the scientific community 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. It certainly has a better meaning than measuring the citations received by their publications. To our knowledge today the region has had no such exercises in measurement of impact of the research activities. More generally, programme managers have been interested in this real-life impact, that translated directly in the research capability, but it is difficult to extrapolate to a whole nation.[16] Most national level exercises are related to using the data that we have presented so far, and drawing attention to some inadequacies. Even the more easy to implement use of a detailed

Table 1: Statistical Variety of Data
In bold: data that has been used for factorial analysis

	Mean	Maximum	Median	Minimum
Gross Domestic Expenditure on R&D -GERD (as a % of GDP) (2007)	**0,32**	**1,20**	**0,20**	**0,04**
Business Enterprise Expenditure on R&D (BERD) rank (134 countries) 2008	**73**	**124**	**69**	**35**
Global Innovation Index Ranking 2012 (out of 141 countries)	**76**	**141**	**58**	**33**
PCT patents applications per million population (Value)	**1,0**	**4,5**	**0,6**	**0,0**
Patents (USPTO patents granted to residents of Arab countries 2008)	**6**	**30**	**3**	**0**
Expenditure on higher education (% of GDP) 2008	1,06	2,04	0,92	0,50
Expenditure on higher education per student 2007	2407	8186	1635	757
Number of university (2006)	**19**	**41**	**18**	**1**
Teaching staff (2004) (MF)	**29952**	**188593**	**10219**	**832**
Number of students (2007)	**501962**	**1776699**	**316362**	**30200**
Number of researchers (2005)	**11233**	**42151**	**4632**	**10,5**
Researchers per 1 million inhabitants (2007)	**571,49**	**3314,50**	**240,00**	**41,00**
Number of publications (2008)	**788**	**3963**	**453**	**13**
Number of publication in Basic Sciences 2005	351	2004	156	9
Number of publication in Natural Sciences 2005	368	1240	144	8
Number of publication in Food Sciences 2005	82	394	63	1
Number of publication in Applied Sciences 2005	388	2174	248	9
Scientific Articles per 1 million population (2008)	**82,8**	**222,5**	**59,7**	**2,4**
Mean Annual growth rate period 2001-04 (publications)	**5,37**	**20,88**	**4,99**	**-8,78**
Mean Annual growth rate period 2005-08 (publications)	**7,21**	**25,47**	**7,29**	**-30,45**
% International Collaboration (co-authorship)	**54,4823**	**98,0960**	**53,0400**	**38,3860**
% World production in SCI	**0,0694**	**0,3200**	**0,0390**	**0,0000**

[16] A recent effort was made to evaluate impact at mid-temer of ERAWIDE projects. See MIRA forthcomin final book.

scoreboard based on publications has not been implemented in any country (not even Morocco where the concept was born).

3. Characterizing the national research systems in the Arab World

This section will present an empirical descriptive analysis of the research systems. We have long wanting to test the significance of indicators commonly used in most publications about science and technology in the Arab World. We would like here to use the most frequently addressed data in a way that guides us toward a typology of research systems. Furthermore, we will try to weave our explanation of the riddle of underinvestment in the Arab countries against this typology by looking at aspects such as the publication pattern, the organization of the research system, the role of universities, etc. This very empirical way of doing is less interested in the ranking of countries (which one can include, as we did) than in the characterization of the important variables and profiles of countries.

Mobilizing the data for the factor Analysis

We have been looking at the type of data available and decided to use most of the standard data that have a meaning at the national level. Macro-indicators are, at best, a way to point to a certain direction. This is precisely what we would like to do here.

We found 114 indicators in the literature and our observations rely on their use. Some of these indicators are redundant or coming from different sources. Table 1 gives the list used finally in the factorial analysis while the listing indicates the general list of variables.

A factorial analysis

Principal component factor analysis was conducted (with no varimax rotation) to assess the underlying structure for 16 of the 22 statistical items gathered on Arab countries belonging to ESCWA. The data were "reduced" to percentile groups in order to eliminate the distortions that could be introduced by the mere size effect, since the variety is quite large as can be seen in Table 1.

Table 2: 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

We can see from this table that there are different types of data:

- Indicators of size; such as the number of professors, students, researchers, volumes of production (in number of articles) and shares of World scientific production, and the 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;
- Indicators based on the General Innovation Index, or the assessment of R&D business investment. These two are extracted from the INSEAD Innovation §§ World

Economic Forum assessment of competitiveness, which publishes a ranking often used to complement the lack of data that exists on these activities.

General list of variables

1. GDP (in billion US$) (2010)
2. GDP per capita US $ (2010)
3. GDP per capita US $ PPP
4. Rank HDI (2007)
5. Total population 2010
6. Growth (%) (2010)
7. PPP gross national income/ Per capita $ (2010)
8. Manufacturing, value added (% of GDP) (2010)
9. Value chain presence (2007)
10. Personal computers per 1000 people (2009)
11. Internet users per 1000 population (2009)
12. Knowledge Economy Index 2012 (out of 145)
13. EFA Development Index (EDI) (2008 Ranking) out of 127
14. Literacy level
15. % Literate adults
16. % Literate young (15-24)
17. % Students/pop that can attend
18. Total enrolment (2004)
19. Secondary enrolment (%)
20. Tertiary enrolment (%)
21. Public expenditure per student as a % of GDP per capita (2004)
22. Public expenditure on education as % of GDP
23. Public expenditure on education as % of total government expenditure
24. Teaching staff
25. Total number of graduates
26. Gross Domestic Expenditure on R&D -GERD (as a % of GDP)
27. Private sector spending on R&D (Rank)
28. GERD financed by abroad
29. % GERD financed by abroad
30. Business Enterprise Expenditure on R&D (BERD)
31. BERD financed by foreign owned companies and %
32. R&D budget / GDP %
33. Technology Balance of Payments
34. Specialized government research center
35. Centers at universities
36. Laboratories
37. Branch research units
38. Technological Research cities
39. Global Innovation Index (GII) Ranking 2012 (out of 141 countries)
40. PCT patents application per million population
41. Patents (USPTO patents granted to residents of Arab countries 2008 / Number of patents in 2005- 2006 /
42. Average annual number of patents (2002-2006)
43. Trademarks
44. Academic Ranking of World Universities (ARWU) 2010
45. Expenditure on higher education (in million) (budget of the ministry of higher education)
46. Expenditure on higher education (% of GDP)
47. Expenditure on higher education per student
48. Number of universities
49. Number of students
50. Number undergraduates
51. MSc Students (2006)
52. Ph D students (2006)
53. Number of faculty
54. Number of researchers (2005)
55. Local Collaboration
56. Regional collab. (with the Arab World)
57. Internat. Collaboration (2005)
58. Researchers per 1 million inhabitants
59. Estimates on full-time equivalents (FTE) (2008)
60. Estimates on full-time equivalents (FTE) per million population
61. Number of Scientists and Engineers in referee journals (2010)
62. Number of Scientists and engineers established in the USA
63. Number of publications
64. -- in Basic Sciences 2005
65. -- in Natural Sciences 2005
66. -- in Food Sciences 2005
67. -- in Applied Sciences 2005
68. Share of Arab publications (2005)
69. Scientific publications per 1000 publications
70. Number of articles per million inhabitants (2005)
71. Scientific articles per million inhabitants (2008)
72. Co-publications (2008)
73. Regional co-publications (2005)
74. Publications in Wos/Scopus
75. Language of publication
76. Specialization index
77. % World shares (2004)
78. Growth of publications (2001-2006) in world shares
79. Government bodies responsible for R&D policies & co-ordination in the Arab world, 2006
80. Existence organization of Min. research, or Ministry of S&T
81. co-ordinations / Funding Agencies, Other funding mechanisms
82. Document that defines the national research strategy
83. Type of Governance in S&T
84. Expenses on Scientific Research (2005)
85. S&T Policy document
86. Brain drain and rank out of 142 countries
87. Company spending on R&D
88. Quality of scientific research institutions
89. University-industry research collaboration
90. Local availability of specialized research & training services
91. Firm-level technology absorption
92. Value chain presence
93. FDI and technology transfer
94. Capacity for innovation
95. Quality of management schools
96. Availability of scientists and engineers
97. Laws relating to ICT
98. Intellectual property protection
99. Efficiency of legal system in settling disputes
100. Quality of math & science education
101. Internet access in school
102. FDI (million US$)

Undertanding the diversity of variables

The five main factors extracted represented 80% of the total variance (Table 2). The first main component accounted for 31.6% of the variance*, the second component accounted for 18.6%, and the third factor accounted for 13.9%. This indicates a quite wide diversity of data.

Table 3: Variables and components (a)

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

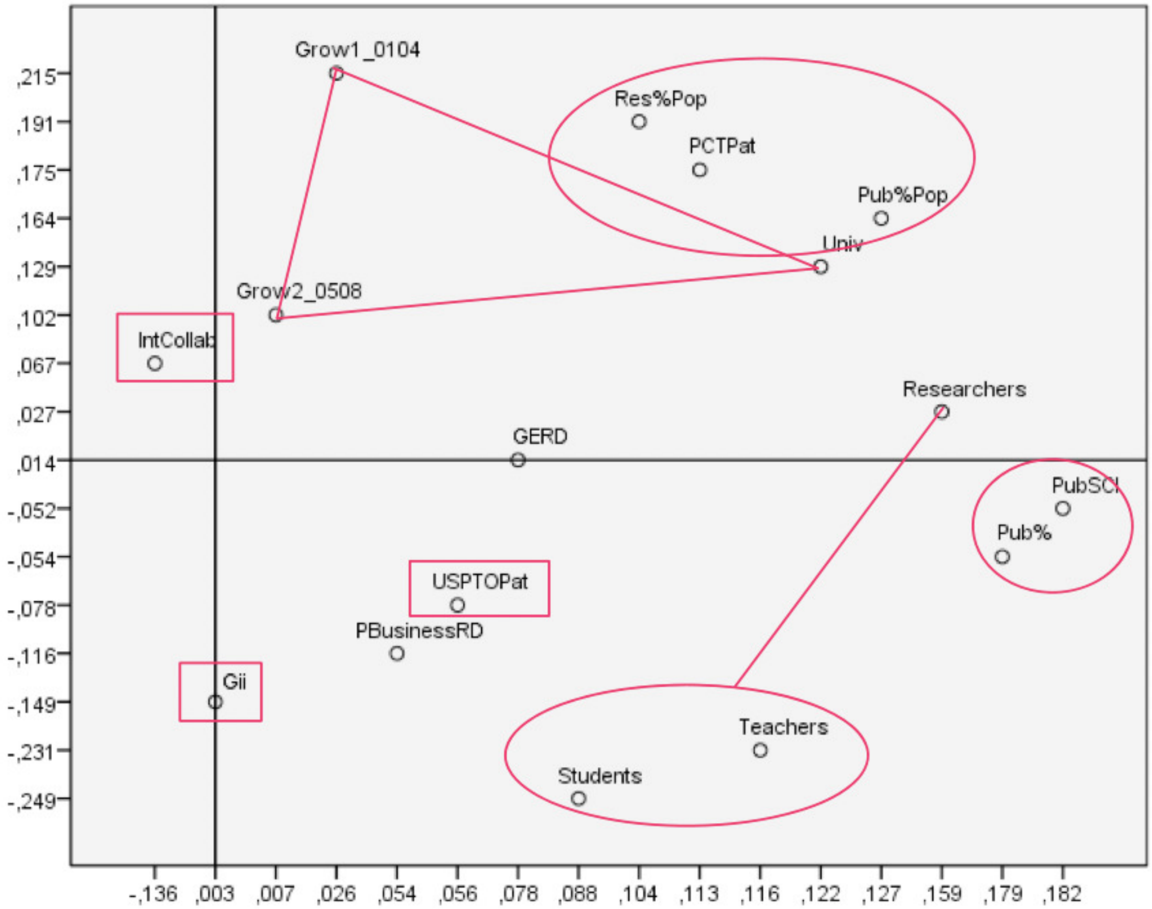
(a) Principal component analysis with no rotation of axis. **Color code**: Red= Negative, blue= Positive. The more intense the color, the higher the value in the component.

Table 3 displays the items and components loadings for the extracted factors (loading above 0,350 are indicated in yellow).

Figure 2 displays the projection of variables on the plane formed by two main axis (or main components).

The first axis, which graphically represents the **first component** (31,6% of the total variance),

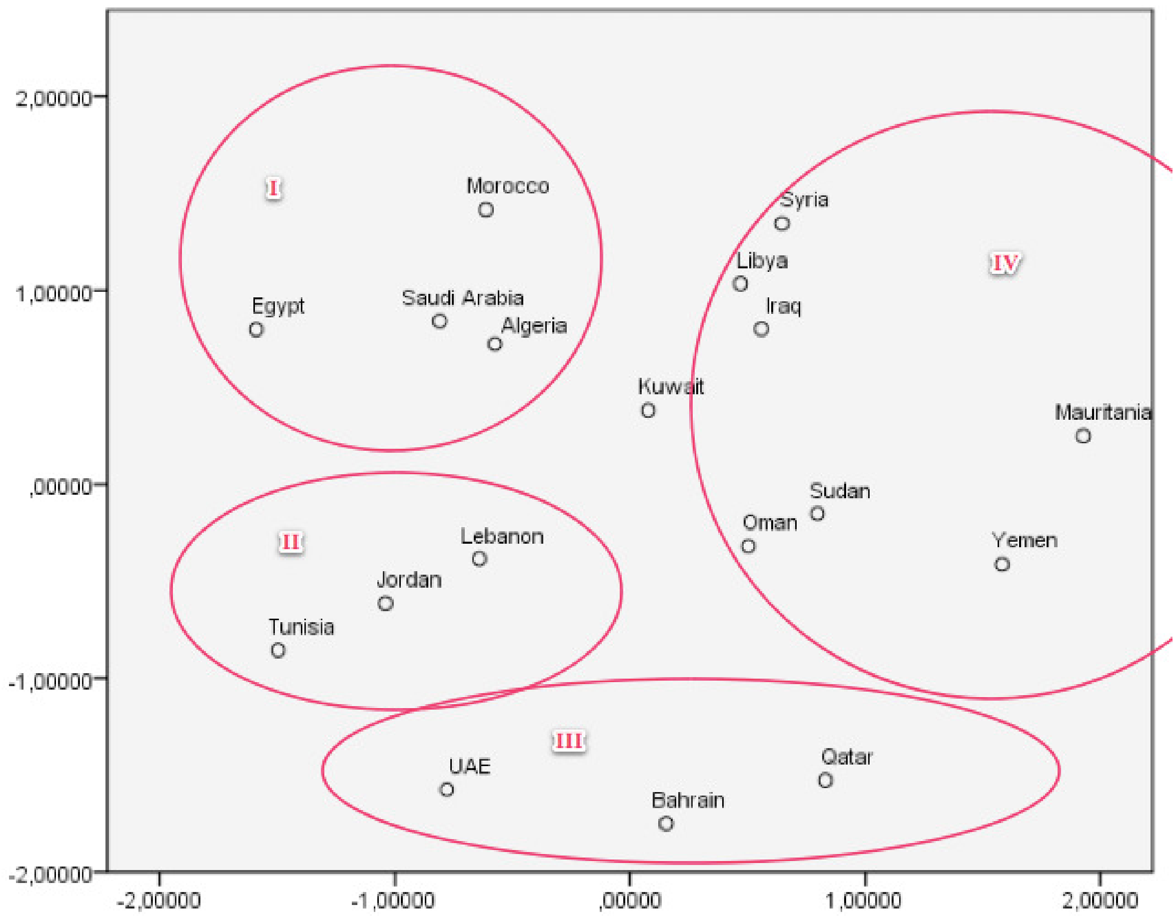
Figure 2: Diagram of Variables



is relatively easy to interpret in substantial terms (not only statistical terms). It identifies, on one side, *the paramount importance given to international collaborations* as measured by co-authorship, and on the other side, indicators of scale (« mass » indicators such as size of the students and teachers population, shares of world scientific production). This means that international collaboration is the variable that differentiates most the profiles of the countries. The axis then somehow indicates that size per se permits to rank research systems, but the close connection to international collaboration is what makes the difference.

The **second component** is represented by the vertical axis. As can be seen from Table 3, 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 quite complex General Innovation Index (GII) indicator, and an indicator of the involvement of the private sector (R&D business expenses as evaluated by the Competitiveness report); as a less important contribution to this component we find patents (USPTO)). Interestingly, the PCT application patents (which are easier to obtain than the USPTO) are represented on the opposite side of this second axis, which in fact can be easily explained by the fact that PCT patents are more closely related to indicators of size than USPTO patents, which are the result of a deliberate strategy of firms for protection of innovation in the USA. 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.

Figure 3: Countries Represented in the space of two main factors



The **third component**, that is not represented in the figure (see Table 3), locates on one side indicators of **output** (patents and scientific publications), and on the other side growth rates of publications (which are dynamic indicators showing the active involvement in research), indicators of size (size of the university system) as well as the GII indicator. This component, thus differentiates between systems that are heavy producers from this that may not be so good producers but still are very dynamic. For Arab countries, which, as we shall see later, have a small contribution in World production of articles in science, this has very unique meaning: the dynamism somehow balances this rather low share. Any explanation concerning the research system should then be able to explain satisfactorily both the low production and the dynamism (and, as a hint, we all would point out the importance of the Gulf countries in the explanation).

The **fourth component**, opposes the more recent growth of publications (Growth rate 2005-2008) to the older one (2001-2004) and to all the more complex and fundamental indicators of the research system (GII, international co-authorship, researchers per inhabitants). This component merely distinguishes between rather newly grown research systems (the Gulf, Jordan) to the "older" ones (Maghreb, Lebanon).

Finally, the **fifth component** more certainly redundant, opposes resources and results; in particular, on one side we find GERD and human resources, and on the other side, older growth of publications (2001-2004), GII ranking, scientific articles per million inhabitants. Interestingly, it also shows as "results" the business involvement in R&D. We can only stress the importance of this finding: R&D involvement is a result and does not only depend upon the size of the university system.

Many messages are delivered by this first analysis. First, size indicators, dynamic indicators, and innovation indicators allow for a typology of Arab countries. Thus next to "size" we saw the importance of the variable of co-authorship: international collaboration plays a very important role in the explanation, and is closely related to the more rapidly growing countries but also to the rather more consolidated research systems. Those possessing high levels of co-authorship (Morocco, Tunisia, Lebanon, Jordan) are rapidly expanding countries, with a longer history than the others, and with a trend towards consolidating their research system. We will also suggest, by looking at specialization patterns, that the countries have also a disciplinary profile that more is different from an engineering-oriented profile. In very recent years, Egypt saw a renewal of its production after many years of relatively sluggish production. It also saw a growth of its international collaborations and a new growth in areas that were largely abandoned before mainly health and biological sciences, to he profit of chemistry and engineering. Only Algeria still sticks to this engineering and material sciences dominant profile, a profile close to that of ... China.

The space formed by the axis one and two (Figure 3) divides variables in size: larger countries should be on the left and the smaller ones should be on the right, while dynamic variables are rather pulling on the lower part of axis one, whereas the size of the university system is rather on the upper part of this space.

Grouping countries by their statistical characteristics: a first typology

Figure 3 represents countries on this same space. We see the larger and dynamic countries on the upper left part, the small and dynamic countries on the lower part, and the less dynamic countries on the right part of the diagram. Kuwait has always occupied a more central position with relative figures in all variables being in middle grounds.

Thus we have four groups of countries:

- Group I: **Rather large research systems and growing slower,** relative to other ESCWA countries. **Egypt, Morocco, Saudi Arabia** and **Algeria**. Rather "rich" or comparatively large countries. Egypt is a case by itself, in this group (or any other) and its lack of natural resources (contrary to the other three) sets it apart. But the group is basically aggregating larger research systems, which also tend to a certain inertia, growing rather slowly, consolidating their international collaborations. Morocco has a particularity of having a recently sluggish growth of production after a period of very rapid growth (explained by the rapidly growing academic population in the late nineties, mostly because of Moroccan returnees). It is the more diversified system in the sample. As we will see later, Egypt and Algeria share a very similar profile of disciplinary specialization.

- Group II: **Small, dynamic and integrated**. **Tunisia, Jordan** and **Lebanon**: small and very dynamic research systems by all standards. These are the countries having the higher records in publications and growth of production. They are also small by any standard but have proportionally high figures of researchers, and of scientific production. Although they have low scores in innovation, these countries tend to have niches of innovative activities. Curiously, Tunisia is a very centralized science policy system, whereas Jordan and Lebanon are not. Had we had indicators to measure this centralization we would probably have had different results. But we know from recent work that Tunisia, Jordan, and Lebanon are engaged in an active pursuit of scientific research, and consolidate the evaluation systems inside their universities. **Kuwait**, which stands in between group I and II, could for analytical purposes be integrated in group II, because of its older strategy to support the university and research system. Only its small size makes it different. Jordan, finally is the country that has changed most recently and this translates in a surge in its scientific production.
- Group III. **Very small and rapidly expanding**. **UAE**, **Bahrain** and **Qatar**, very small and rich Gulf countries, with an active policy in developing technologies and universities, pursuing active "branding" strategies for their universities, and trying to make most out of their high-level resources.
- Group IV. **All other countries**. It is quite difficult to differentiate between them. They are rather small and less integrated research systems. Some universities seem to be developed but figures are low on many grounds. Iraq stands in this group since it still

Table 4: Four intuitive institutional models in Arab countries

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

Source: ESTIME - own presentation.

has not engaged in the reconstruction of its once well-known university system.

4. The governance of research systems

In a former research project (ESTIME), four models of governance concerning the Arab World were identified, by stressing the degree of centralization of the system, as well as the relation to the economy and the society (Table 4). We would like to engage a discussion on the governance of the research systems by taking this first, intuitive, categorization into account before proposing a renewed typology.

HISTORY

We can see that the models proposed in table 6 are related to the historical precedent and not to performance. It makes sense to take into account history because it shapes institutions and also the research path of a country (see introduction).

Arab research centers at first focused on basic sciences, and medicine. They subsequently diversified their programs to include in general applied specializations. During the last two decades, human, social, and environmental sciences have also been added. More focused centres have been created, usually because of the availability of some specific (and international) funding. For instance, there is a focus on locally significant palm tree research in a number of Gulf countries; traditionally, agricultural research, depending on agricultural ministries, in Egypt, Syria, Morocco, and Sudan, have been quite important; international agricultural centres like ICARDA (HQ was based in Aleppo) belonging to the CGIAR network have also played an important role in structuring the research in this field; desertification, water pollution and management of water resources have been promoted by French bilateral cooperation mainly in 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 an international funding on environmental sciences. Many research projects are currently being implemented by partnerships with Western industrial states and the exchange of scientific visits and training.

Egypt currently has the largest number of research centers (fourteen specialised government research centers, 219 research centers under the auspices of ministries, and 114 centers at universities). In Tunisia, there are thirty three research centers comprising 139 laboratories and 643 branch research units.[17] Technological research cities are few and are limited to Egypt, Saudi Arabia, and Tunisia (UNECA, 2008, in French). Some new research and practice cities are under way in the Gulf countries (see box 2). There is a generalized tendeny to promote technopoles, technoparks and ‘science cities’. Apart those mentioned in Box 2, we can mention the Science and Technology Oasis that functions under the umbrella of the Qatar Foundation (UNDP, 2009:188). Tunisia has had the most ambitious technoparks system which is somewhat not growing as quickly as official declaration would like it, but still has been effective in some cases (see section of national innovation systems).

CENTRALISATION

[17] 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

Second, the relation to the state is very central: larger countries usually have a more "centralized" science policy system. But centralization can also be the case of smaller countries, like Tunisia which has a centralized system/ Moreover, centralisation has no relation with performance. A totally decentralized system like Lebanon –an exception in the Arab World –is as performing as Tunisia, a small and centralized system. The figure of a 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. But under this gross generalization we should be careful: Egypt, is in a process of rapid "decentralization" of its science policy: dismantling its Science Academy and giving birth to a quasi council and programme-based funding (STDF), follows an original course that has no historical precedent in the country. The same goes for Morocco which under an apparently centralized country is experiencing a collection of state initiatives coming from competing Ministries and the King's Makhzen. All are in competition for rare resources.

In most Arab countries research is an attribute 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 (Lebanon, Kuwait, Bahrain, the UAE, and Qatar) show an exception to this trend, having assigned the task of research and development to relatively independent councils and academies (Nabil 'Abd al-Majid Salih, 2008, in Arabic; UNDP, 2009:188). In Lebanon, for example, the National Centre for Scientific Research (CNRS) has mainly functioned as an agency distributing research grants on the basis of competitive calls for offer. The CNRS has also four institutes of its own, but these have are kept in a small size.

In most Arab countries, scientific research agencies are attached to, by and large, higher education systems, rather than to production and service sectors. A. Zahlan in his assessment believes this has contributed to the creation of a wide gap between education and research on the one hand and economic and social needs on the other. We would be less affirmative on this aspect: changing the attributions of research from higher education to industry does not really modify the state of play. In practically all rab countries, there has been a rampant competition between 'modernists' usually to be found in 'technical Ministries' and political personnel more preoccupied with the National representation and the central power play. Education is usually one of the more central places where this competition is expressed. Higher education, has been profoundly affected by the global changes and the pressure on universities, to a point that goes well beyond the usual willingness of the State apparatus to control student life and potentially rebellious universities. Research can difficultly find its way in this very strenuous political pressure. This also explains the predominance of ministries of industry, agriculture, and telecommunications in the innovation policies. Hospitals are also becoming a very central site for research as they are both a place of useful (and popular) research as well as a strong employment pole. A multiplicity of research centres and actors is thus growing. That is also true in all countries; because of this, innovation policies insist rather on coordination functions rather than production and funding, the usual functions of a central governmental structure in charge of research policy. It is a new and important aspect that is difficult to implement (Arvanitis, 2003).

DYNAMISM

The four institutional models do not take at all into account the dynamism of the sector, a key variable as we stressed in section 3. In fact, this dynamism is present in countries where

Table 5: 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 %
		Council	Ministry				
Algeria	Yes (Nat.Plan, 1998)		Yes		Nat Res progs + National Fund RTD + .	Centralized	0,25 *
Morocco	Yes (Vision 2006)		Dept of a larger minister (since 2004)	CNRST	Various Funds to support innovation: PTI, Incubators	Centralized	0,8 *
Tunisia	Yes (5th Plan & following Plans since 1977)		Yes	Nat Sc Res Foundation (since 1989) Et al.	Various Funds to support innovation: FRP, NPRI, PTI, Techparks	Centralized	1,0 *
Egypt	No	Formerly: Ac. Of Sc.	Yes	STDF and other funds	Initiatives from various Ministries: Agri, Indus, Telecom, etc.	Centralized	0,2 **
Lebanon	Yes STIP = Vision (2006)	Yes CNRS	-	CNRS Since 1962	Performers get contracts from all sorts of sponsors	De-centralized	0,22 *
Jordan	No	Yes HCST	-	HCST since 1987	Performers get contracts from all sorts of sponsors	De-centralized	0,34 *
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 & strategic planning	-		Sponsors	Trade oriented	0,2
Qatar	_		-	Qatar Foundation	Sponsors	Trade oriented	0,6 **
Kuwait	_	Still in discussion	Yes Min High Edu & Sctf Res	KFASFunding & coord since 1988	Sponsors	Trade oriented	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 ESTIME project, Satti (2005). *On-going work.*

science and technology are not only declared as useful but also where important investments have been made. As we will show below, money by itself does not guarantee the performance, but it clearly is the concrete translation of a political engagement in favour for research. The factorial analysis, in particular, shows that differences in growth rates as well as performance on the Global innovation index do make a strong difference. Explaining this dynamism should be the focus of science and technology studies in the region.

PERFORMANCE

Performance seems not related to these ‘structural’ aspects as policy centralization, history or institutional organization. Tunisia, leading Arab country in research, has a centralized science policy, as is the case of Algeria and Egypt which have shown a lower performance (Figure 3 presents a simplified illustration of the institutional arrangement of science and technology in Tunisia). Its research system, nonetheless is rather fragile because it depends upon too many changes and nominations inside the public administration. Moreover, Tunisia, more than any other country shows the extreme difficulty in triggering technological research, and innovation from within the research system (we will return to this point in the section on the national innovation systems) (M’henni & Arvanitis, 2012).

A UNDP report states that the creation of various projects under foreign funding results in persistently weak impact (UNDP, 2009:187- 188). Here too, we believe no one has developed the tools to really measure impact of these projects. In some cases, the available funding locally is insufficient: one such very intriguing case is that of the technical centres in Tunisia devoted to technological research for the productive sector. As they grow, they are seeking for more funding and despite their declared usefulness to national development they need to respond to international calls for projects (mainly European). This is a quite common situation and the EU has responded favourably either as EU or by bi-lateral cooperation. MIRA project has formalized this demand by promoting a Euro-Mediterranean Innovation Space. Whatever the case, we want to repeat that monitoring the technology and innovation policy in the region is still not done systematically and statements of low or high impact make little sense (Arvanitis and M’henni, 2010)

Models of research governance and policy

If we attempt to make a synthesis of this discussion based on the factorial analysis and the more intuitive “institutional models” presented above, we can depict three models for the governance of the research system.

1. Large rather centralized but growing research systems
2. Centralized and rather low performing systems.
3. Smaller dynamic systems
4. Small flexible and market-oriented systems

Group 1: Large centralized but dynamic research systems

Size matters in research. Many have tried to find an ideal “critical mass” under which size would explain the under-development of the research capacity. After thirty years of looking at this mythical “critical mass” we might reconsider the fact that size is also the translation of a certain diversification of interests and stronger expansion of the research system. If this dynamic process takes place, not just because the population is wide, but because the growth of the activity is regular and strong, then we can state that we are in presence of a dynamic research system that creates opportunities. This is the case of Morocco and Saudi Arabia; more recently, Egypt which is undergoing a major overhaul of its research system, and Algeria, which has finally decided to heavily invest in research, are part of this type. They are also centralized countries but seem to be able to manage the emergence of competitive funds and favour collaborations with foreign partners. With the exception (very notable) of Egypt, they are "rich" countries. Egypt is a case by itself, in this group (or any other) and its lack of natural resources (contrary to the other three) sets it apart. But the group is basically aggregating larger research systems, which also tend to demonstrate, next to dynamism, a certain bureaucratic and institutional inertia. They are growing, but rather slowly, consolidating their international collaborations. Morocco has the particularity of having a recently sluggish growth of production of publications, after a period of very rapid growth (explained by the rapidly growing academic population in the late nineties, mostly because of Moroccan returnees). It is the more diversified system in the sample. As we will see later, the remaining three (Saudi Arabia, Egypt and Algeria) share a very similar profile of disciplinary specialization.

Group 2: Small dynamic systems

We find here countries whose centers are characterized by flexibility in their relationship with the public sector, and diversity in their funding sources 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 an explicit research, yet they are also characterized by the frequently brief tenure of their experts and their intensive domestic and international travel (Tunisia, Lebanon, Jordan, Kuweit). The countries of this model are the Group II in our factor analysis, ie. Small dynamic and integrated. They have the higher records in publications and growth of production. They are also small by any standard but have proportionally high figures of researchers, citation impact and strong (proportionally) scientific production.

Table 6: Scientific Research Sources of Financing in Arab Countries

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

Source: UNESCO (2009: 541)

Group 3: Centralized and rather low performing systems.

Centralization can also be the translation of a bureaucratic relationship with the public sector. A small research activity, disseminated in few research centres, limited in its funding to the state contributions, with no diversity in their financial or human resources, is the trademark of this group. Syria, Libya, and Sudan demonstrate this grouping. It is also countries that have had (or still have) a political trauma. Iraq is probably part of this grouping and its recent effort to regain its former shine is very noticeable. In these countries, the public research centres are burdened with scientific services required by public utilities, or under the pressure of teaching. Universities have a limited research record. As such, these countries' contribution to the production of original research and patents are limited and they do not include all scientific specializations. These countries belong to Group IV of our factor analysis, ie. countries that have rather small and less integrated research systems. Some universities seem to be developed but figures are low on many grounds. Policy in this case would be rather different than the one needed in Group 1. International recommendations seem geared to these countries, but they do not represent neither the core nor the most important group of countries.

Group 4: Small flexible and market-oriented systems

The fourth model is quite similar to group 2, because it concerns small countries, but rather more centralized, and with research centers are characterized by flexibility towards, and sometimes independence from, the public sector, as well as by diversity of funding sources, and the ability to attract specialists from abroad and guarantee the relative stability of national specialists. A significant percentage of their scientific production comes from universities and private centers, and they are able to benefit from international cooperation programs, as well as from independent national support funds (UAE, Qatar). The countries of this model are in Group III in our factor analysis. This group has very small and rapidly expanding, very small and rich countries, with an active policy in developing technologies and universities, pursuing actively "branding" strategies for their universities, trying to make most out of their high-level resources. Table 6 shows the rare effort of public sector (2.9%) in financing research. They have been emblematic countries of the 'knowledge economy' because they have been applying quite strictly some of the recommendations about private research funding, creating private universities, adopting international standards, and so on. As a study showed on science cities, these countries have been very responsive to policy at the international level and to a large degree have been applying recipes for success. What this apparent conformity to a perfect model shows is also the difficulty in creating a research community from scratch. Its an experience that was travelled by Singapour (Goudineau 1990). The complexity of the route from a policy recommendation to a full-fledged system should not be under-estimated.

Table 7: The quality of Arab research institutions (2008)

Country	The quality of Arab research institutions according to executives surveyed by the World Economic Forum (2008)	
	Rank among 134 countries	Rank among Arab countries
Qatar	30	1
Tunisia	42	2
Jordan	51	3
Saudi Arabia	52	4
Kuwait	54	5
Oman	59	6
UAE	74	7
Syria	89	8
Morocco	94	9
Egypt	96	10
Bahrain	100	11
Algeria	108	12
Turkey	52	-
Malaysia	20	-

Sources: UNDP & Al Maktoum Foundation, 2009:189

This categorization is not perfect. Its purpose is to engage a discussion on different policy making according to the situations we are facing.

Box 1. Science citites in the Gulf countries

Hiba Khodr (AUB) studied the governance of three specialized "science cities" in Dubai, Abu D: the Dubai Healthcare City, the Abu Dhabi Masdar City, and the Qatar Education City. They are quite exemplary of the governance style of these entirely new entities that combine a hospital, schools, universities, and science.

“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 the policy development and formulation. […] These decision makers they 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 government, semi-government organizations, or government-funded projects. They are also located in resource-rich countries. They aim at the diversification of the economy and, in their design and policy objectives, at sustainability.

The author 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. H. Khodr writes : “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.

H. Khodr, 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 on-line) http://www.aub.edu.lb/ifi/

5. R&D and investment

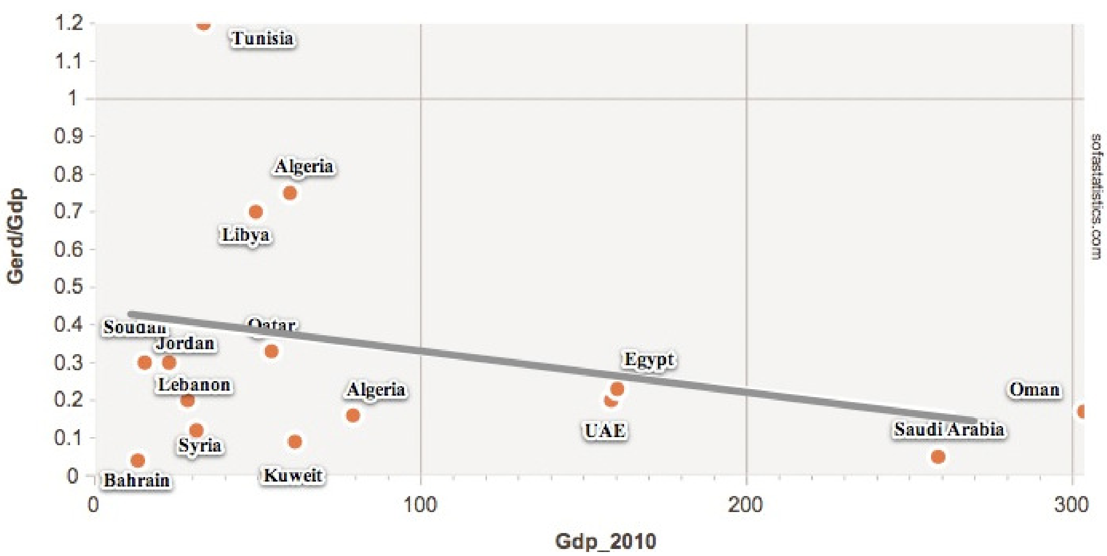
We just saw that Gross expenditure on research and development (GERD) occupies a middle position as a differentiating indicator: it not closely related to any particular profile of countries. Of course larger countries will tend to spend more. But overall there seems to be a sort of indirect contribution of funding in defining the research systems.

Table 8: Distribution of Countries According to GDP/head & GERD (% 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) (1)
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	1976	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	2232	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	

Notes: (1) World Bank, Knowledge Assessment Methodology (KAM), 2008. * GERD as % of GDP: COMSTECH data ** GERD as % of GDP: National Council for Scientific Research (CNRS).
Source: Arab Knowledge Report, Table 5-4, p.193

Maybe a cautionary note should be given on financial input data used in this report. Most relay n estimates and our field experience is that the data are currently not crosschecked. 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. Neither are the ministries that may have be in charge of industry, agriculture or other services. In the specific case of telecommunications and information technologies, Ministries of telecoms have had specific initiatives: it is the case in practically all the Maghreb countries, Egypt and Lebanon. Also authorities in charge of foreign investment have had in practically all these countries regulatory power and as such have tried to produce specific data on the sector of telecoms. But rarely has that been 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 and/or research. This is a not the best way to have confidence in the data: these entities are reporting on the data their administration will be judged upon by other administrations and central power structures. Moreover since practically more than 70% of the expenses in R&D are public expenses, and these are largely channelled through central state budget, ministries in charge of finance or budget may not be incited in having these expenses statistics 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, usually used by international organizations, are strikingly different than any other sources/estimates. Methodology for these data is not published. We know that UNESCO, through its Montreal-based Institute of Statistics, has been undergoing a process of validating data in the Arab region and we can only encourage this effort to be pursued. The aim here is not only to give more transparency regarding public statistical data but also to give more confidence to non-public entities (in particular private companies) on the way the State reports on research and innovation.



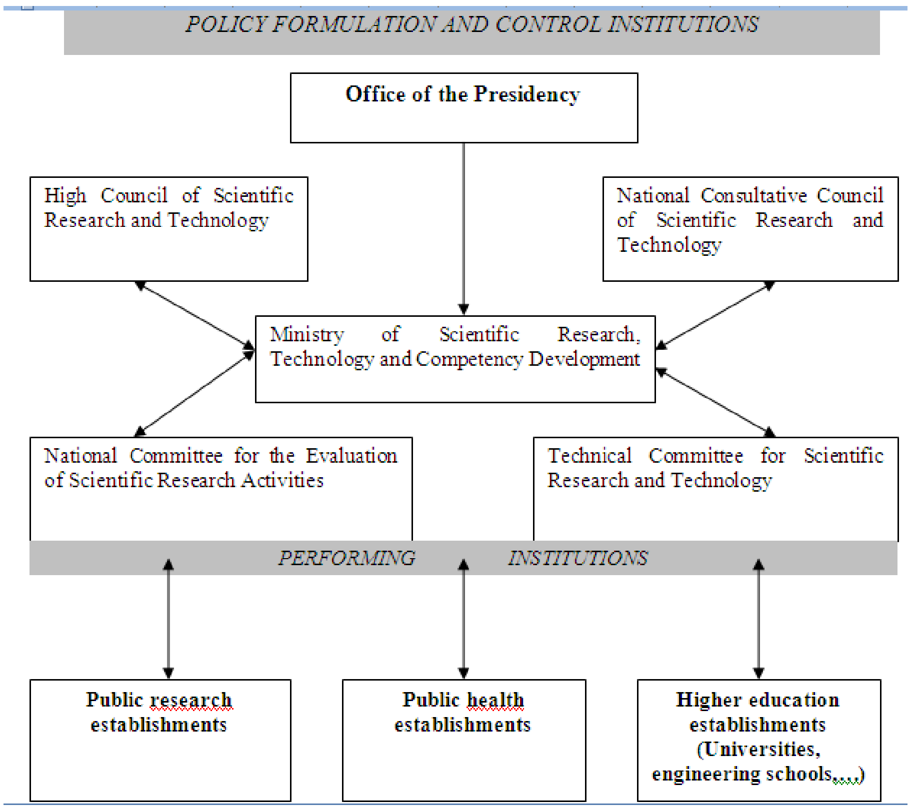
Note: R=-0.293 ; p= 0.290 (p>0,01 : not statistically significant)

Figure 4. Correlation between GDP and GERD to GDP ratio

Moreover, there are discrepancies that may put serious doubt on certain figures. For eg., some countries report both high GERD and low contribution to education as a whole: it is the case of Sudan and Qatar. Of course this is for different –even opposing– reasons. Nonetheless, the greatest 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% and 1.2% of gross domestic product (GDP). OECD countries devote about 2.2% of GDP to research and development (R&D). There are signs of change however (Table 8). Egypt's GERD has remained stable at about 0.23% since 2007, but before the Arab Spring changed the politically

Figure 5: Simplified Illustration of the Institutional Arrangement of S&T in Tunisia - Public Sector Research (2008)



Source: Arvanitis & Hanafi, forthcoming

landscape in Egypt, the government planned to raise it to 1.0% over five years. It also engaged into the reform of the governance of research and innovation, based on more competitive funding, larger funds for public universities for research and more active government structures. Although the Revolution went by in the middle of this reform process, it seems that these orientations for S&T will be maintained. Something similar happens to Tunisia. Before the Arab Spring, Tunisia's GERD had been climbing steadily since 2000 and, in 2007, it was the leading Arab state for R&D intensity, at just over 1.2% of GDP. It will probably maintain its advantage acquired after practically 10 years of institutional modelling that has been, until now, hardly challenged by the new government elected in Tunisia (see M'henni and Arvanitis, forthcoming). Saudi Arabia, whose per capita GDP is the fifth highest in the region, adopted a national plan for science and technology in 2003. It still ranked second to last in 2007, however, in terms of R&D spending as a percentage of GDP (0.05%, ahead of Bahrain at 0.04%).

There is no congruence between GERD neither with the GDP nor with GDP per capita. The interest in research is indeed not linked to GDP in a simplistic, linear fashion. Some rich countries proportionally do not invest in the development of science (such as UAE). But this relates to the capacity to spend on research activities; and the capacity to spend the budget is not related to the GDP but to administrative capabilities and institutions. In fact, one can see, that UAE is among the countries having the highest growth of publications in the last ten years. Indeed, this is not related to its very high GDP. Much depends on the will and interest of the government, political system, and ambient values-especially in relation to religion, colonial history and international support. Since Arab authoritarian regimes often force many Arab scientists to flee their countries, they do not contribute to the GDP of their countries, as they reside in Western countries.

However, the private and productive sector also possesses part of the responsibility. Over the next three years, more than half of the companies surveyed for this report expect to increase the level of their R&D investment in the Middle East. This result is slightly skewed, however, by the presence of local companies in the survey. Among those companies from outside the Middle East and North Africa, around 40% plan to increase their R&D investment in the region over the next three years. Also, public companies that are run as private businesses but have a real monopoly (or monopsony) are systematically under-investing in research. After a review in the Mediterranean countries, a working group on innovation in the MIRA project concluded that some very few large companies report R&D activities like Sonade in Tunisia, Sonatrach or Cevital in Algeria (Khelfaoui 2006). Morocco seem to be in a slightly better position but in most cases it related to very highly profitable companies exploiting natural resources. Without talking about Oil and petroleum resources, such a large company as OCP in Morocco (among the largest phosphate producers in the World) invests 1% of its sales into R&D (sales were estimated around 7 bn USD per year). A large part of that investment is not related to internal R&D but to the so-called “open innovation” which consists in contracting and out-sourcing research. The example concerns a company that has a rather favourable prospect for R&D. Moreover, Morocco is having a sharp increase in R&D investments in very strategic areas, not limited to foreign investment.

Foreign investment is usually called after, in order to provide more R&D. In fact foreign

Box 2. Establishing joint stock company for the promoting of research
The Egyptian Ministry for scientific research approved the establishment of public-private joint stock companies in support and care of ideas and patents, and the execution of scientific researches outputs that it will present to the public with a capital of 100 million pounds.

The establishment of this company comes in the frame of the new strategy sponsored by the ministry to be the mediator among researchers, scientists, investors, and business men, which would contribute to the development of the ministry’s role, which had been limited to receiving the results of research. The new role performed by the ministry in this company is dependent on its sponsor and the type of research and projects that will be executed, and is concerned with the application and transfer by the company to the industrial and production region, with emphasis on translating the results of scientific research into projects and products that will benefit the Egyptian citizen.

companies when they invest in R&D do little for local technological upgrading. In Tunisia, foreign owned enterprises are not having such a large impact in the economy. The analysis of the innovation survey shows foreign companies do not invest in R&D and do not invest in innovation either. More generally, and contrary to the current *doxa*, we can affirm that foreign direct investment although can be very profitable is not really interested in developing R&D or innovation into the local economies. This has been the observation for example in China where more than 400 R&D centres belonging to foreign companies have opened. None of these seem to relate that investment with local technological up-grading except in the value chains related to the companies owning these R&D facilities (Bironneau 2012). Studies on the R&D strategies of large global companies tend to confirm this, and there is no reason why ESCWA region would be an exception.

For the most part, R&D centers in the region are currently relatively small, and generally focused on late-stage development, rather than "blue sky" research (Economist Intelligence Unit, 2011:4). Only recently have we witness the establishment of the new initiatives of new partnerships between the private and public sectors in promoting R&D (read Box 1). Moreover, after some difficult experiences, Maghreb countries have shown that technology transfer units form university to the productive sector to be relatively inefficient (or totally so, as Morocco has recently admitted when launching its new innovation support plan in 2011). Most support given to R&D and innovation in the economy by national authorities is directed toward SMEs, based on the claim that in MENA economies, SMEs form not only the largest bulk of companies (up to 95% of companies in most countries), but also that they provide the main part of employment. This preferential direction toward SMEs has been the basis of all "up-grading" programmes (or "mise à niveau" in French), from Mexico to Tunisia, passing by Chile or Thailand. The EU has been very keen in funding these up-grading schemes in North Africa. The results are always far below expectations and usually it is claimed that the fault lies into the programmes and their management . We might also need alternative explanations, after so many years of testing up-grading. What is at need is rather a diversification of economic investment: support to large investment projects in highly competitive areas (even by providing direct support to large companies, something all large economies are doing on a permanent basis); strong support to innovative projects in smaller entities whatever the sector but with regularity and accompanying the company growth (which is what company incubators are all about); strong support to middle-sized companies (around 300 employees) that have a verified record of technical success and strong economic strengths but insufficient investment capacity; all this, instead of the usual university-managed (and inefficient) technology transfer units or the small loans to tiny companies with no economic prospect.

From fieldwork done in many universities and technological poles or incubators, it appeats that successful experiences, both entrepreneurial and innovative-wise, are rather more numerous than is usually assessed. That was the result of all innovation surveys done in Morocco and Tunisia. The Egyptian survey on innovation has been less convincing and that probably reflects a rather more difficult economic environment than Maghreb countries. Strangely, the international comparisons do not reflect any of this information when

The Arab Knowledge Report mentions the initiative in Jordan known as "A professor in every factory" (promoted in 2003) which focuses on sending an academic in factories in summer vacations. Another recent initiative, funded by a common EU-Jordan fund has been the SRTD programme (a 4 million Euros programme) that funds innovation-related actions in enterprises. Most of these programmes have been directed to SMEs.

In Jordan, a decent level of R&D spending in the private sector was noticed: 30% of R&D expenditures as compared to the 70% of the public sector (this figure appears as the highest in ESCWA countries). There is an incubator (Oasis) of 500 with a proven record of transforming entrepreneurial ventures into viable businesses (SWOT analysis of Jordan Science System, ESCWA). 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", others have only simple units of research. They have had in most cases a quite difficult conversion to R&D (Khelfaoui, 2004: 80).

In brief, when we use the GERD as a measure of a state's 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 $10, compared to the Malaysian citizen's annual share of $33. Record levels spent in small European countries are higher, such as the case of Ireland and Finland, where annual expenditures on scientific research per capita reach $575 and $1,304 respectively (UNDP, 2009:193).

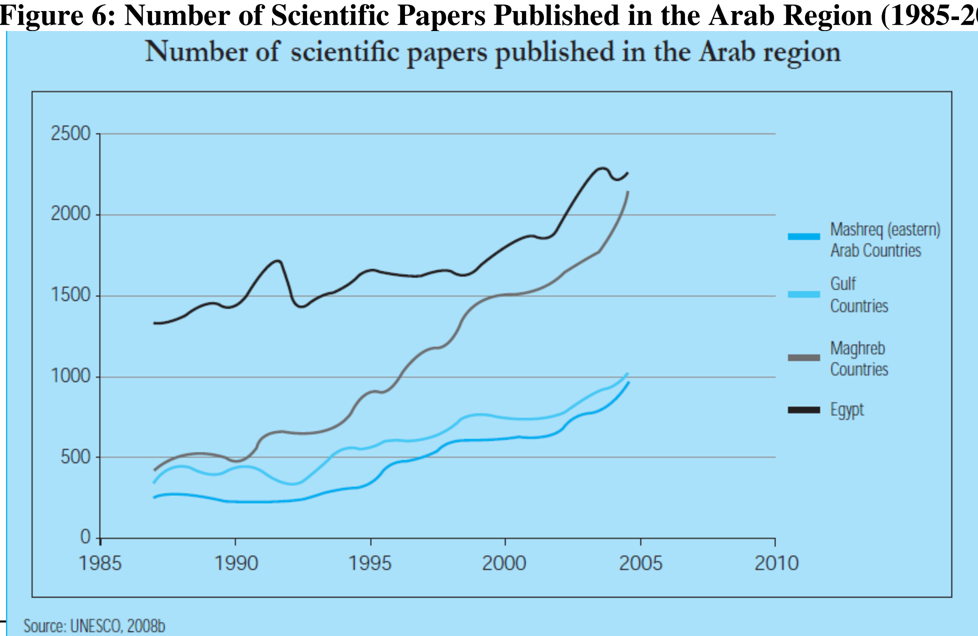
Foundations for research

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, 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 of 2008.18The set-up of the European Union–Egypt Innovation Fund, in 2008, the fund will support projects for applied research on a competitive basis, with special emphasis on innovation (Mohamed, 2008; cited by Mouton and Waast, 2009).

6. Scientific production

Usually scientific production is measured by indicators based on two types of data: the number of the publications in referee international scientific journals and books, and the citations received by the published articles. Studying the use of citations is only possible using the Web of Science (WoS by Thomson Reuters), and SCOPUS (by Elsevier). These two databases are not the only ones but they are the only ones containing citations. Specialized databases, or other large multidisciplinary databases are usually not used in

Figure 6: Number of Scientific Papers Published in the Arab Region (1985-2010)



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

Sources: UNDP & Al Maktoum Foundation, 2009:196

bibliometric analysis. There are bad and good reasons to that. The main (good) reason is that one needs to have some stable reference in order to do comparative analysis. From this point of view WoS is supposedly more stable than SCOPUS, although its has been shown that both are delivering similar results. This holds true for large countries ***only*** and for statistical analysis on domains/fields with a large number of publications (because of statistical size of the sample of publications). It is probably not true for national-based data in particular in countries with small production; that is practically all countries in the ESCWA sample. A real full-fledged analysis of bibliometric data done with care for the region is still needed.

Another issue with databases is their coverage of certain fields. It appears that they underestimate certain domains, while on the contrary they tend to overestimate others: for instance, the biomedical sciences are better covered by the WoS. Books –and other forms of publication more frequent in the social sciences and humanities—are badly covered by both databases (that are nevertheless currently trying to at least partially cover edited books). Every single small journal in the US of any small university is covered in the social sciences index, but many largely circulated journals outside the US are missing: it is true for Europe as well as for other countries of the World. The underlying model of WoS and SCOPUS is a commercial world whose centre is the USA, a model that has been challenged even in disciplines of the so-called 'hard' sciences.

We have been looking at the case of the American University of Beirut in order to see how much of its production is not reported in the international databases. The example makes sense because the AUB has a good level of publications in English in large journals. The

Table 9: Growth rates of some Arab countries and comparison

	Morocco	Algeria	Tunisia	Egypt	Jordan	Lebanon	Syria	Chile	Thai	South Africa
Scores SCI 2006 (+)	756	728	1079	2743	421 *	481 *	146 *	2972 *	2235 *	3330
‰ World shares 2004(++)	1.26	0,73	1.08	3.42	0.69	0.48	0.16	3.04	2.43	4.64

Source: SCI 2006 ou * SCI 2005. Non expanded. Integer counts. (+) Calculation P.L. Rossi / IRD; (++)Calculation OST.In Arvanitis 2007 ESTIME Final Report.

unreported publication record can be relatively high.[19]

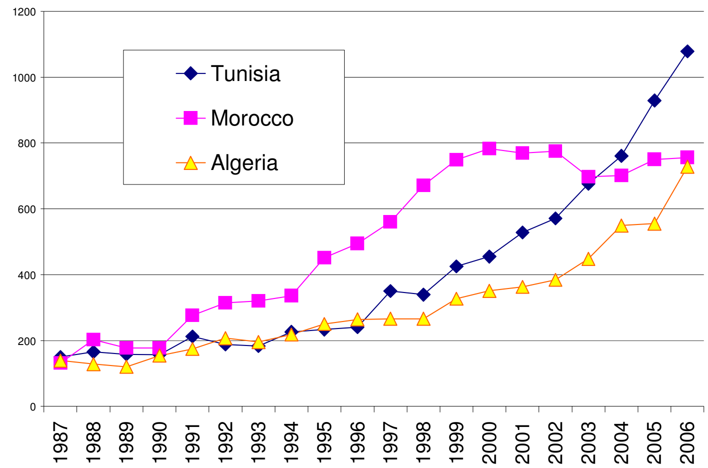
A rapidly growing scientific production

The mere numbers of scientific articles is still low in the Arab Countries. A recent report underlies that in 2007, the level of Arab scientific publications (approx. 15,000 papers), was equivalent to that of Brazil and South Korea in 1985 (Mrad, 2011). Moreover, the number of articles published per 100 researchers each year was only 2 in four countries, 6 and 38 in two further countries, and was around 100 in Kuwait. If the total number of Arab university

[19] This is an on-going project. Results will be delivered by the end of 2013.

teaching staff is calculated at 180,000 doctorate holding university professors, and if we add around 30,000 researchers working full-time in specialised centres, then the academic-scientific corps working in Arab research and development can be estimated at 210,000 researchers. Yet this body of specialized scientists produces only 5,000 academic papers per year, equating twenty-four scientific papers per 1,000 university professors and full-time researchers (UNDP, 2009:201).

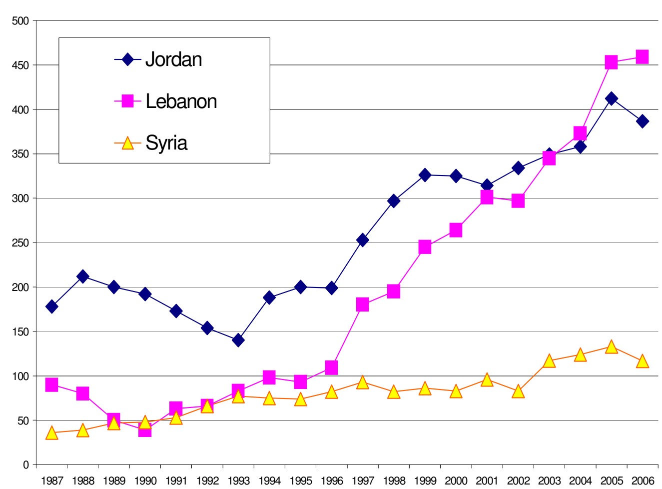
Figure 7: Evolution of the Scientific Production of Maghreb Countries (1987-2006)



This is the result of the general underinvestment in research that we have already mentioned above. What is reassuring however is the fact that the growth pattern in the last twenty years is impressive. Growth rates are always above the world growth rate of publications, and comparable to three countries emerging countries that are comparable to most Arab countries: Chile, Thailand and South Africa. The whole region was still invisible to computation some twenty years ago and represented more than 1.5 % of world production.

The main cause for this growth is the extremely strong growth of the Maghreb countries. Morocco has had a previously stronger and longer growth period (see figures 6 and 7). Tunisia has quadrupled its publication (from 540 in 2000 to 2026 in 2008) and its world share reached 2.05, while Morocco showed little progress (from 1041 to 1167 for the same period); it should nonetheless be reminded that Morocco has known a very strong surge of production from 1998 to 2004. Algeria has also known a more recent rapid expansion. Jordan, and Lebanon have also shown rapid growth, as well as UAE, and Saudi Arabia. Egypt has had a sluggish growth since early 2000, with a surge of production in the last six years. The reason probably lies in the new

Figure 8: Scientific Production of Middle-Eastern Countries (1987-2006)



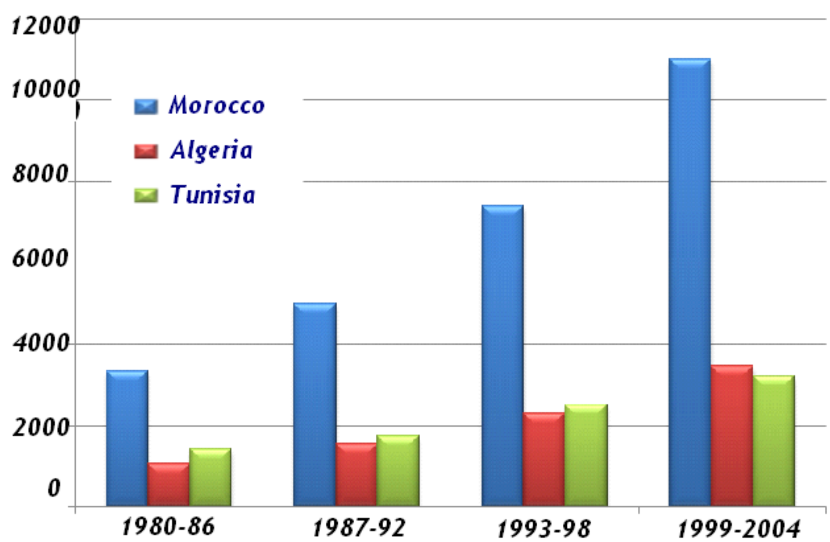
effort to promote research and the science policy to invest in research. Funding was increased and the possibilities to work in collaboration with foreign scientists have been reinforced.

In terms of book production, twenty Arab countries produce 6000 books per year, compared to 102,000 in North America (Lord, 2008). There are as many translations published in Greece in one year as in all Arab countries (Mermier, 2005). This relatively low production in the Arab World has been the topic of many discussions.

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

In the social sciences, we have no good information sources for publications. There is however, one notable exception which is the Maghreb countries. In Casablanca, the Abdulaziz Foundation keeps the best and quasi-exhaustive record of production in the humanities and social sciences for all the Maghreb countries. It also keeps track of the publications in the humanities and social sciences produced elsewhere that focuses on the Maghreb region. This very exceptional source of information has only been used once to our knowledge for bibliometric purposes (Waast, et alii 2010).

Figure 9: Academic Publications in Maghreb Social Sciences & Humanities (1980-2004)



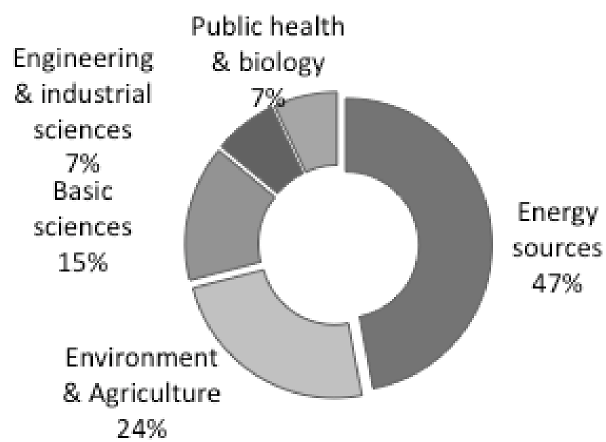
Source: *Fondation Abdulaziz,* Casablanca. Processing by IRD.

Figure 6 shows the growth pattern for the three main Maghreb countries. As can be seen, Morocco has experienced a very sharp increase in its production in the early years of 2000. The content of the database has been examined in depth. It should be noted that the growth of 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 database. Moreover, the Abdulaziz database has been showing the highly differentiated forms of production in fields such as History, Economics, Sociology, and Anthropology. It showed the dominance of the humanities (literature studies, philosophy, and religious studies) and the surprising decline of economics publications. The latter is even more surprising knowing that Business Management is among the most rapidly growing areas of study in practically all Arab countries.

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). We notice the particularly small percentage for basic science (15%) while energy sciences (engineering mostly) occupied 47%, followed by the environment and agriculture (24%). Engineering in all senses is the dominant Arab disciplinary domain in most countries, with some notable exceptions (Tunisia and Lebanon). The research strength of Egypt, Morocco and Algeria lies in chemistry; in fact when one looks at the production it is very much organic chemistry, chemical engineering and physio-chemical characterisations for specific materials. The research strength in other countries is clinical medicine for Jordan, Kuwait, Lebanon, Oman, Saudi Arabia, Tunisia and the United Arab Emirates. Syria's strength lies in plant and animal science – but it is an artefact due to the presence of ICARDA, an international institute belonging to the Consultative Group for International Agricultural Research Centres in Aleppo, which specializes in these fields, whereas Qatar makes its mark in engineering (Naim and Rahman 2009, cited in UNESCO, 2010: 263).

Figure 10: Scientific articles according to domains (1998-2007)



Sources: UNDP & Al Maktoum Foundation, 2009:198; COMSTECH data source.

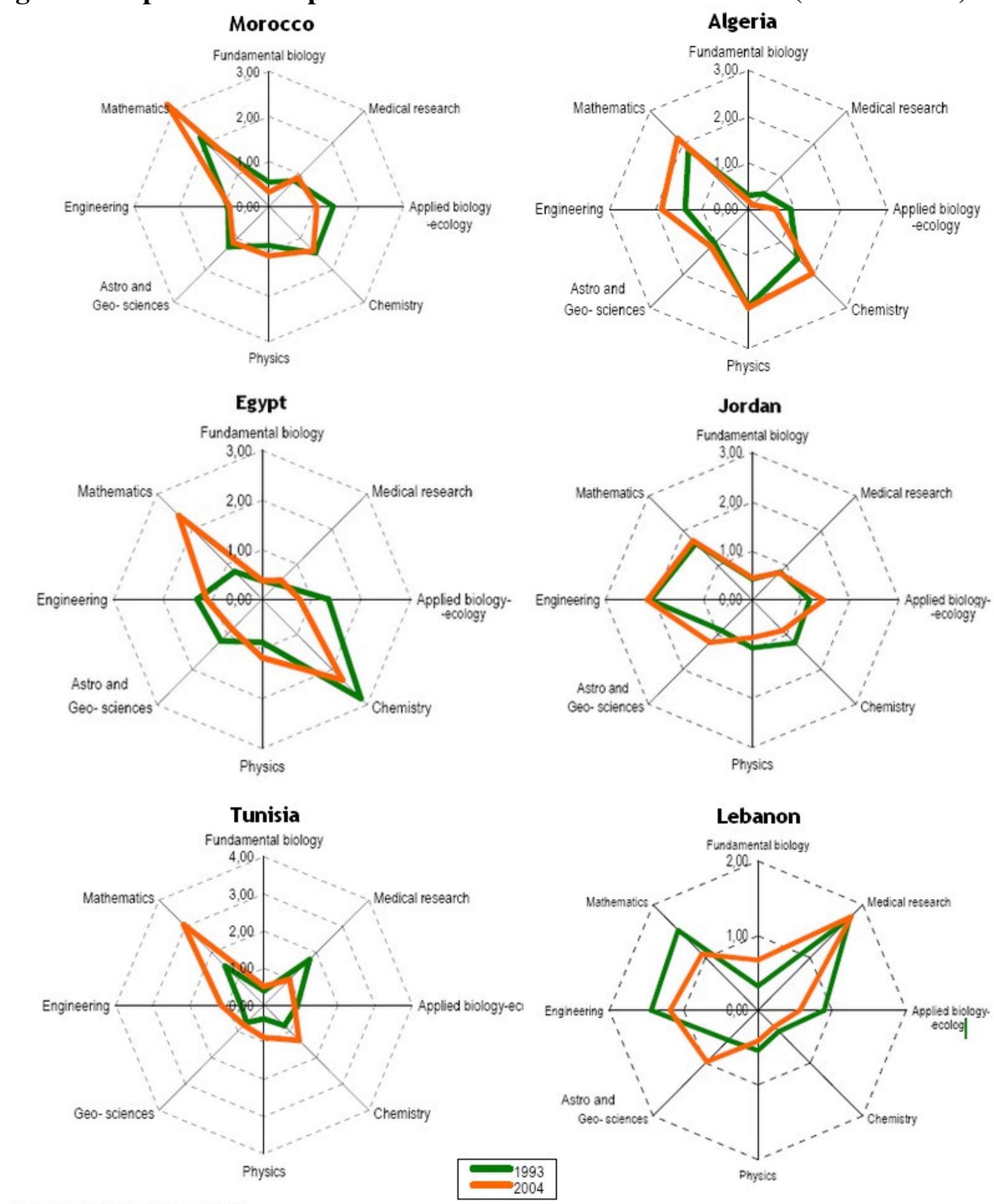
Figure 10 shows the specialization patterns for six countries and compares 1993 and 2004 (WoS data). What is quite evident is that the specialization patterns are very sticky over time. In 8 domains, the specialization patterns of these six countries are very much similar over time. Two exceptions can be noted: a relative surge of mathematics in Egypt as compared to the previous situation –but it should be reminded that this specialization concerns a very small number of articles; and the relative growth in biomedical research in Tunisia. Contrary to the former case, the growth of production in the biological and biomedical research concerns the majority of scientific production of the country and thus translates a strong emphasis in the biomedical domains. Research in Tunisia has not only grown in spectacular figures; it has also been oriented toward life sciences and biomedical research.

Tunisia has thus become closer in its production profile to Lebanon which, as can be seen in Figure 10 and 11, is very different from other countries. The case of Lebanon is very special: it has a strong medical research, related to the two large hospitals (Medical Center of AUB formerly known as AUH, and Hotel Dieu de France) both related to two large universities

(AUB and USJ). There is also a growing number of publications from Lebanese University and Balamand University both having a related famous university hospitals. Nonetheless, most of the production of Lebanon in this area is related to AUB and its Medical Center which has a historical precedent in the region, being the oldest university in the region. Moreover, AUB has deployed a strong effort in promoting scientific production of its personnel and this translates in its overall production figures.

Jordan is also moving towards this pattern, although from a typical engineering-dominated

Figure 11: Specialization patterns in six selected Arab countries (1993 & 2004)

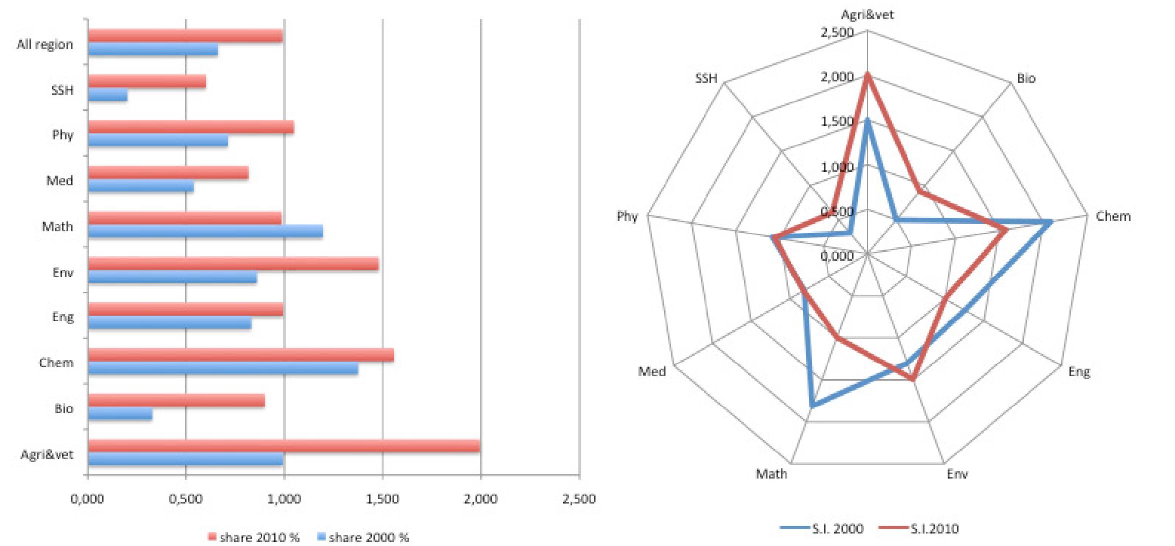


Thomson Scientific data, OST computing

Source : Data Thomson ISI, SCI Expanded. Computing OST landscape of research. It is now evolving towards more research which can be based on a recognized medical capability. Nonetheless, still the dominant figure in Jordan remains engineering-related areas of specialization.

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

Figure 12: Specialization pattern of ESCWA region as a whole (2000-2010)



Note: Left graphic represents the share of ESCWA 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.
Source: compiled by us based on Scopus from http://www.scimagojr.com/

For more overview for other Arab countries, see the Annex 1 that shows the specialization patterns for Arab countries (percentage of publication in each specialty from 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 had the most important change in the 10 years of interval: Tunisia has pushed a lot its production in the Agricultural sciences and diminished its specialization in Mathematics. Egypt, most importantly because the size of the production involved is more important, has considerably diminished its over-specialization in Chemistry. This is good sign, because in this particular case, most of the production in chemistry was the production of routine analysis on specific chemico-physical characteristics of materials. On the contrary we see a smoother production spread in in various domains. It is also striking to see the similarity of the specialization profile of Saudi Arabia and Egypt (low in Medical sciences and biology, high engineering). Finally, it interesting to compare two very similar in size countries (Jordan and Lebanon) with quite different profiles. Jordan has stronger emphasis in Engineering and environment, and –surprisingly –social sciences. As a cautionary we should mention that social sciences in these data are low figures (and probably more sensitive to changes in the specialization indicators). Lebanon on the contrary has a stronger specialization in biological sciences, agricultural sciences and Clinical Medicine. Interestingly there is slowdown of the medical specialization in Lebanon to the profit of the biological sciences, the more basic sciences. This is probably a sign of strengthening research.

The overall pattern of specialization and growth for the ESCWA region as a whole, 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. On this new orientation, toward environmental science, we believe the production has been influenced by the increased funding towards environmental sciences, in Europe mainly but also internationally.

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 citation of a single paper from the USA is 3.82 (among the highest figures are located in the US), and from South Korea 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 for other Arab countries. These very low figures of received citations do not relate to language, since the data come from English-speaking material published and reported by the two only databases that include citations (Thomson's WoS and Scopus).

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 measure the quality necessarily –as was usually defended 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 in not cited at all. Since measures based on citations depend upon time, many indicators have been proposed to take into account this age factor. The H-Factor is one of the most popular measures that precisely was designed by Hirsch in order to record this effect of age in relation to citations and publications. The logic behind the H-factor is that the longer a career, the more probable the citations. A way to take both this cumulative effect into account but not give it a decisive advantage is to detect the number of citations received in relation to the number of publications. The H-index, in our case, is a country's number of articles (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 to this result it would have needed to published much more than 30 publications. The index measures somehow a certain permanence.

The issue here is that the H-index can vary a lot with some articles that get a very high score 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 associates researchers from other countries with very high citation scores. The H-index has its own drawbacks but is primarily problematic when used not on an individual but for a group or an entity (can we say a "country is publishing"? Strictly speaking a country is only a statistical entity and the "publications" of a country is the sum of individual publications). The variety of publication and citation practices across fields is undermined by this indicator. Fields known to be highly productive, both in term of papers and of citations, impose thus 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 as follow for the whole period 1996-2010 (see Table 10). As a comparison, let us remind that the USA (an outlier in all these statistics) has an H-index of 1229, followed by the UK (750). Farther behind, Germany (657), France (604), Canada (580), Japan (568), and Italy (412). The core countries of Europe have

Table 10: Scientific production & 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	Libyan Arab Jamahiriya	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

H-indexes for these 15 years (1996-2010) between 20 and 30. Other Middle-range countries, have figures ranging from 20 to 35. China has a relatively low 53, meaning the number of papers received a high flow of citations is low. It should be noted that the H-index is indeed sensible to the size of the production (the more you produce the more probable it is to receive high flows of citations), longevity and regularity.

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

Issues related to impact

The most famous bibliometric indicator is the "impact factor", which measures the mean number of citations received by a Journal on the total number of articles published by the

Journal. It is very different from one field to another, it is not very robust (and thus easily varies), and has many statistical difficulties. There has also been a strong controversy regarding the use of the Impact factor which in part is due to the availability of the indicator that is regularly published by Thomson Web of Science (in its science citation index reports) and exists since Garfield introduced it in the nineteen sixties. 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 (Monastersky, 2005).

The citations measures have been encouraging a certain concentration of production into journals that are registered in the WoS (formerly ISI) database, which were once thought to represent "mainstream science". This poses a real difficulty to countries that do not have a large history of science publication, since the game seems strictly limited to a very small number of players.

Table 11: Local journals in databases (countries around the Mediterranean Basin)

	Scopus	SCI+SSCI + A&HCI (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	**2084**	**792**

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

The real difficulty for Arab countries is that pressure for publishing in these very few "recognized internationally" journals discourages production in local journals (Hanafi 2010). Arab science periodicals that are included in international databases number no more than 500, about a third of which are published by Egyptian universities and research centers. The rest of these are distributed among Morocco, Jordan, and Iraq. Arab science journals suffer from fundamental problems such as irregular publishing, lack of objective peer review of the articles accepted for publication, 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, which makes many researchers and academics prefer to publish in international, peer reviewed journals (UNDP, 2009:200).

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 WoS databases is partly responsible for the low figures. But the inclusion of journals is usually based upon regularity and readership. The databases do not include them on these grounds. A researcher has recently done a census of publications in the two databases that are produced in countries bordering the Mediterranean (see Table 11) found a decent amount of local Journals in countries where the research system is consolidated. A large country like Turkey counts now 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.

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 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 (see for instance (Glänzel 2001; Adams, Gurney et al. 2007; Schmoch and Schubert 2008; Mattsson, Laget et al. 2008).

As has been reported (Gaillard, Gaillard and Arvanitis, 2010), in 2006, 30% of the world's scientific and technical articles had authors from two or more countries, compared to slightly more than 10% in 1988. One-quarter (26,6%) of articles with U.S. authors had one or more non-U.S. co-authors in 2006; the percentage is more or less similar the Asia-8[20] and slightly lower for China and Japan (NSF and OST, 2008). Between 2001 and 2006, international co-publications have increased in all countries except China, Turkey and Brazil. The higher EU-15 level (36% in 2006) partly reflects the EU's emphasis on collaboration among the member countries as well as the relatively small science base of some EU members. Other countries' high levels of collaboration (46% in 2006) reflect science establishments that may be small (e.g. developing countries) or that may be in the process of being rebuilt (e.g. Eastern European countries).

It is thus well known that developing economies have had high and growing co-authorship figures and the smaller the country, the higher this proportion of co-authorship (Gaillard 2010). Co-authorships tend to be proportionally lower for larger countries that have a growing scientific community. Thus, China, Brazil and Turkey are the countries where the number of co-authorship has lowered (as percentage of total production), as a result of a very rapid growing scientific production and a diversification of its scientific community.

Table 12 shows the production in 2000 and 2010 and the share of co-publications for these years. As can be seen co-authorship is extremely high for small producers (UAE, Syria, Qatar, Libya, Yemen, Sudan, Mauritania). It falls in middle ranges for larger producers. Egypt has an exceptionally low figure of co-publications. A small check with on-line data would show that the share of co-authorships is now growing also in Egypt as in other countries. About half of the production with co-authorship seems to be a standard situation.

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 to an emphasis in publication in refereed international scientific journals.

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

The evaluation of journals where to publish by the use of the impact factor, is encouraged. This has consequences on the publications and prestige of universities.

In order to understand the way publications of a university department are distributed, we studied the amount and type of production of publications accounted for by the international databases, as well as those that were 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 factor journals. We examined the total production of knowledge

Table 12: Publications & Co-authorship in Arab Countries (2000-2010)

Country	Documents 2000	Documents 2010	% Collaboration (2000)	Int. % Collaboration (2010)	Int. Share World (2000)	Share (%) (%) World (2010)
Saudi Arabia	1835	5739	26.1	56.2	0.15	0.26
Egypt	2858	8459	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	2062	30.46	41.46	0.05	0.09
Lebanon	448	1259	38.4	54.6	0.04	0.06
Kuwait	568	1050	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	2059	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	2862	51.5	52.5	0.04	0.13
Libya	72	468	34.7	51.9	0.01	0.02
Morocco	1184	2277	51.4	47.6	0.1	0.1
Tunisia	755	4415	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/

under many forms (articles, books, manuals) of the professors from 2006-2010. We discovered that the WoS and Scopus only capture 31% of the publications reported by

Table 13: Sources of documentation of publication of the Faculty of Arts & Sciences & Faculty of Agriculture (AUB) - by field of science

Field	Total Publications	Total publications in WoS/Scopus	% of publications in WoS/Scopus	% of invisible publications
Humanities	138	16	12	88
Social Sciences	150	29	19	81
Basic sciences	260	170	65	35
Applied sciences	163	55	34	66
Total	711	270	38	62

professors in the annual reports of the Faculty of Arts and Sciences and in the Faculty of Agriculture at the American University of Beirut.

The rest is thus ‘invisible’ in the databases but may be visible outside the academic community. It might be also production that relates 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 it local society.

As expected, we find that the proportion of invisible knowledge in the humanities and social sciences to be very high (88% and 81% respectively), and less for applied Sciences (66%); it reaches one third for the basic sciences. Thus, the issue is not confined to the social sciences and humanities, but in all sciences with varying degrees.

Discussion

Many reasons explain the relatively low production in science in the Arab countries. The reports that have previously studied the subject mention many of these. We would like to recap some of the issues.

- *The role of the university promotion system*

Most researchers in the Arab world belong to high education institutions. The promotion system used there profoundly affects the professors' production. 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 documents required as evidence of production. Another issue is the balance between publications and other types of activities.

- *The research policy of high education institutions*

Many professors would probably engage in more research if the universities relied on an explicit statement favouring research, which is rarely the case. Moreover a research policy congruent with international tendencies needs a certain analysis capability that is rarely found at the level of universities.

- *The lack of good Arab science journals*

Journals published in Arab countries and in Arabic are rare. Local periodicals of good scientific stature should be encouraged, not as academic department information papers, but as disciplinary relevant ventures. This would promote the image of science in society; it would help young researchers publish, and provide a venue for the diffusion of local scientific

Figure 13: Sources of Documentation of Publication of the Faculty of Arts & Sciences & the Faculty of Agriculture (AUB) - By Fields of Science

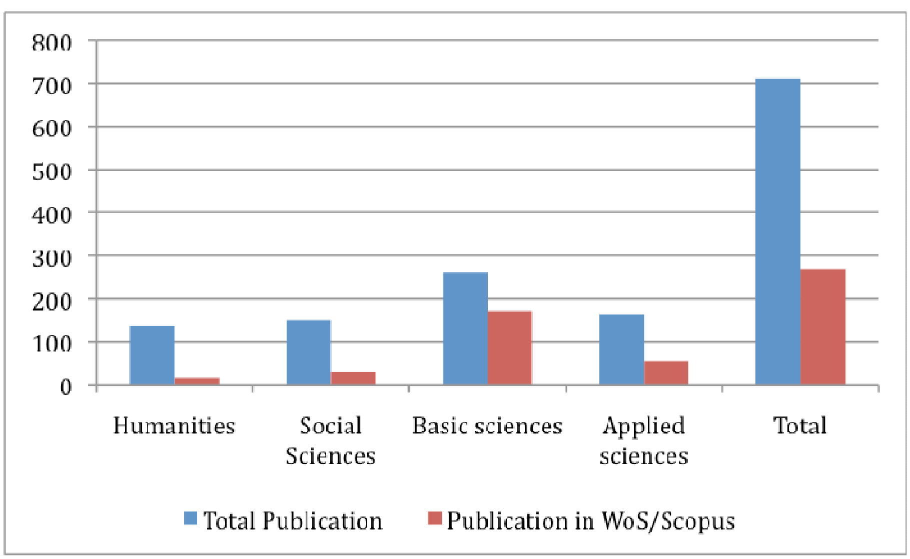


Table 14: Organizations Producing Research in the Palestinian Territory

Type of Centre	Number	%
NGOs: Research Centre	13	31
NGOs: Development and Advocacy Centers	16	38
NGOs: Development, Advocacy & Research Centre	9	21
University Research Centre	4	10
Total	42	100

Source: S. Hanafi and IFPO database for ESTIME project (2007)

activity. But some diseases should be avoided, such as irregular publishing, lack of objective peer review, and irrelevant topics.

- *Engage in a systematic analysis of impact of research programs*

A notable effort is being made in creating 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" that was produced after a series of experts' workshops in the MIRA project (see MIRA 2011).

7. Specificity of social sciences research

Compared to this large picture of research and innovation, there is somehow a specificity of the social sciences.[21] In this section, we would like to raise two points: first concerning the place of production of the social science, and second concerning the status of social sciences in the Arab world, and the attempt of their delegitimization.

Place of production of the social sciences

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

Scholars from Maghreb involved in the ESTIME project clearly indicated that the phenomenon of research centers, taking the form of NGOs, is not very widespread. However, the case of the Arab East is quite different. Research centers, either 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 the Palestinian territory (after Oslo 1993), and the second concerning economic liberalization in Jordan and Egypt. The keyword for the donors was "the reinforcement" of civil society. These centers produce either research or pure consultancy, i.e. very short research where the output is often an unpublished report.[22]

The survey carried out in mid 2000s by Sari Hanafi concerning research centers in the Arab East, 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 without university settings, and second, by NGOs specialized in development, advocacy and cooperative efforts (like The Lebanese Center for Policy Studies).

[21] For an overview see the World Social Science Report, 2010 (UNESCO).

[22] IFPO and ESTIME have established in 2005 a database for research centers and researchers. Among the 54 research centers, there are 27 centers which published research labeled as grey literature: "En général les ONG 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)

For instance (Table 14), the Palestinian territory demonstrates that research production is very much marginalized when it comes to university affiliated institutions (only four centers constituting 10%)23, while the predominant number of organizations are NGOs. Some 41% of the organizations producing research are specialized bodies while the rest are NGOs specializing in advocacy and development.

However we have two specific cases in the region: on one side, Syria and Lebanon, and on the other side, Egypt. In Lebanon, the university is still the bastion of research: according to the ESTIME survey, 85% (60 out of 71) of the researchers studied are affiliated with Lebanese universities (IFPO 2007). Syria has the same situation 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. In contrast to other countries, Egypt constitutes a specific case where the importance of public research centers in social sciences is a phenomenon that dates back to the 1950s. Egypt holds the National Center for Sociological and Criminological Research (NCSCR) based in Cairo, as well as the semi-public institution Al-Ahram Center for Strategic Studies. Other centers are university affiliated, like The American Research Center in Egypt (ARCE), which is also based in Cairo.

Table 15: Organizations related to research activities in Jordan

Type of Centre	Number	%
Private research centres and consultancy companies	23	31
NGOs	20	27
Governmental institutions	16	21
International institutions	13	17
Library or documentation centres	3	4
Total	75	100

Source: S. Hanafi and IFPO database for ESTIME project (2007). This number is reduced now to only 61 active organizations.

In Jordan we find a diversity in the status of research organizations, but more importantly, we find the sweeping majority of the organizations outside the premises of universities (Table 15).

Maghreb countries show the highest output of social and human sciences research, whereas Egypt and the Mashreq (eastern) Arab countries are characterized by relative stagnation this field (El Kenz, 2005). 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 in Beirut, and 5 per cent at the National Council for Scientific Research. The situation is comparable in 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, Syria, Libya, and Lebanon, more than 80 per cent of social science research is produced through research centers or consultative agencies outside of universities, especially

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

in Palestine, Jordan, and Egypt, and to some degree in the countries of the Gulf (UNDP, 2009: 202).

Status of the social sciences: Attempts of delegitimization.

The authoritarian political elite, as well as some religious authorities, take advantage of the tumultuous birth to delegitimize these sciences. It is very rare to hear about any '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, but not as an independent body, or as servile agents who have no say in anything except to justifying the government's decisions. The good social scientists were either in prison, exiled or assassinated (Samir Kassir, intellectuals in Algeria, Syria and Tunisia, professors in Egypt who don't dare to open their mouths, practically half or maybe more of the social scientists of Algeria). We may evoke what one of the intelligence officers once told one of us : "All of my group (ie. dissident social scientists) fill less than one bus and can be brought into prison"! Without overestimating the importance of a handful number of people in social change,

Box 3: A Tumultuous Development of Social Science in the Arab World

"The essential task of Arab sociology is to carry out critical work with two threads: a) deconstruction of concepts that have emerged from the sociological knowledge and discourse of those who spoke on behalf of the Arab world, marked by a predominantly western and ethnocentric ideology, b) and simultaneously a critique of the sociological knowledge and discourse on various Arab societies carried out by Arabs themselves" (Khatibi 1975: 1) [translated by us]

This quote suggests a problematic relationship between the heritage of the Western social sciences and the local Arab societies. We join Alain Roussillon (2002) who argues that sociology in the Arab World was part of the colonial project. Orientalist texts such as the five volumes of the *Description de l'Egypte* (Description of Egypt) map out this intent. During the latter part of the colonial period, and especially after independence of the Arab states, an indigenous sociology or *sociologie musulmane* (Muslim Sociology) emerged. It attempted to decipher the specific nature of the segmented Arab society and yet retained partially an Orientalist position, by investigating its "exotic" culture. Nonetheless, sociology developed in close relation with the development national project.

Only since the seventies have social science fragmented 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 engineering of society. In this way they were at the service of a political process, namely the making of a new society. We think particularly here at Algeria, Nasser, Arab Nationalism, and Marxist analysis. However, they were was at odds with part of the society because of this engineering. We speak of the 'culturalists' in the Algerian independence that were set aside by the 'modernists' (El-Kenz, 1997a; 1997b). 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 that was labelled as the national project. This project, whether communist, socialist, nationalistic, 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 instead being critical of them.

generally speaking, Arab authoritarian states have always underestimated the salience of "bus people", whether they are intellectual, and more generally the thin middle class, in stirring protests. We are thinking particularly of the Tahrani middle class and educated youth in Arab countries. The 2011 Revolutions in Tunisia, Libya and Egypt confirm us in this aspect.

Religious authorities often felt threatened by social scientists, as they compete for the same object: the discourse on society. An example, from a study one of the authors (SA) did in 1994 on family planning in Syria, revealed TV debates with strong tensions between religious leaders, such as Sheikh Mohamed Said Ramadan al-Bouti, who clearly pointed out that Islam is against any family planning, and the anti-clericalist General Union of Syrian Women - a state-sponsored organization. While this topic is par excellence part of the domain of sociology and demography, no social scientists were ever consulted in this public debate.

In this perplexing trajectory, delegitimization is reinforced by the way social scientists conduct their analysis. We argue that both producers of social knowledge in the West and in the Arab world create what we call the "mythology of uniqueness". The Arab world was thought as a place of cultural specificity and exceptionalism, or Muslim immigrants as an incompatible ontological category predicated on culture (Yilmaz 2012). Many still persist in seeing our societies as either a collection of religious devotees or segmented tribal groups. Exceptionalism constitutes a digression from the real debate on societies, politics and culture in the Arab world, (Kabbanji, 2011), especially when it comes to analysis of social class. Samir Kassir (2004) was calling this the "lament of the Arab", showing it clearly was an exceptionality historically constructed. Instead of properly problematizing the mediation between structure, culture, and individual or collective agency, national/religious culture becomes the supremacy as explicative and salient factor. Instead of studying Muslims or the Arabs, there are studies of Islam and Arabic.

8. National systems of innovation

As mentioned in the introduction of this report, innovation is different from research, and not all innovation is research-based. This is why innovation needs a special attention, distinct from research but at the same time related to research. Innovation policies have been developed and sustained quite firmly in the last 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, Syria). Gulf countries have set-up also specific measures. It should be added that the European Union in the framework of the so-called "Barcelona process" (EU-Med cooperation) has also been suggesting more innovation-related actions for EU-Med cooperation in the hope of the set-up a "Euro-Mediterranean Innovation Space" (EMIS) (Pasimeni *et alii*, 2006). Many international organisations, bilateral donors and NGOs have participated in the need of the countries to transform their development models from low-cost into knowledge-based production: the EU, the OECD, UNESCO, UNIDO and ALECSO are only a few examples to name. Finally, the World Bank has actively promoted the policies in favour of knowledge and innovation (Reiffers, 2002).

A specific emphasis was put by funding agencies and governments in the development of techno-parks and industrial clusters (Saint Laurent, 2005). 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 sector and the productive companies in many forms: engineering networks, promotion of technology transfer units, fiscal measures, promotion of start-ups and venture-capital funding. Finally, at varied degrees,

Table 16: Patents Granted to 13 MENA Countries by US Patent Office (1977-2009)

	Number of Patents	% of total
Saudi Arabia	324	40.75
Kuwait	127	15.84
Egypt	97	12.20
UAE	77	9.68
Lebanon	58	7.29
Morocco	42	5.28
Jordan	24	3.01
Tunisia	18	2.26
Oman	8	1.006
Qatar	8	1.006
Algeria	5	0.628
Bahrain	5	0.628
Yemen	3	0.377
Total	795	100%

Note: Stats for 01/01/1977-31/12/2009

Source: http://www.uspto.gov/wen/offices/ac/ido/oeip/taf/cst_all.htm

all the MENA countries were profoundly affected by the EU, which served as an example by its own promotion of innovation and instruments set-up to measure it (such as the European Innovation Scoreboard).

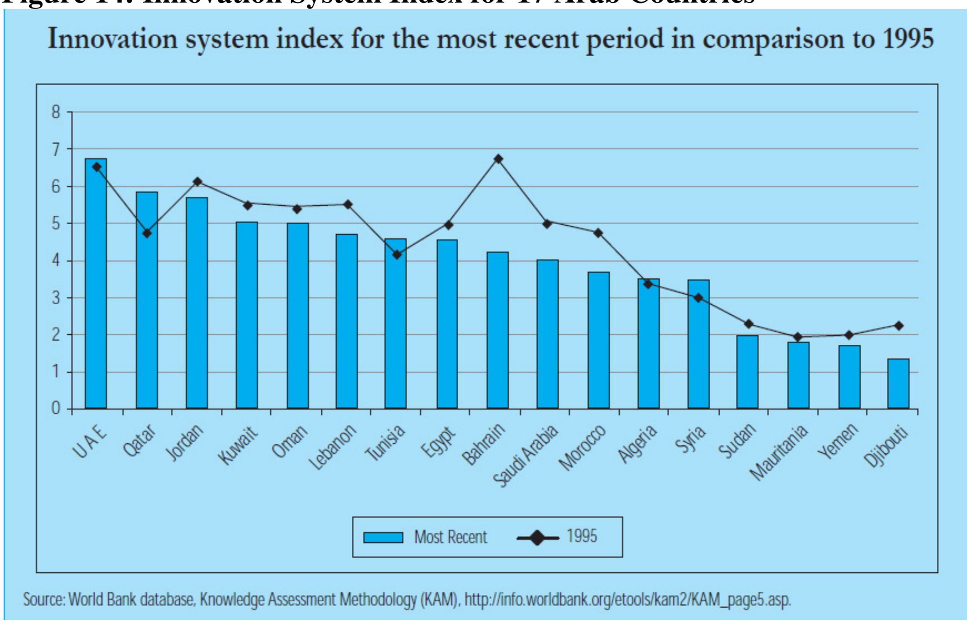
In Western industrial countries and those with growing industrial economies, , there is a positive correlation, between the country's position on some ' innovation index' and the growth of their GDP. Arab countries, however, do not show such a positive correlation between GDP and innovation (Mouton, 2009). 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 & 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, recently many science parks were established in many Arabic countries. First in all Gulf monarchic (Qatar, Saudi Arabia, Kuwait, Bahrain, Oman and the United Arab Emirates) represents a move towards partnerships in innovation between private and public R&D, and this can explain the relative optimistic opinions from business executives on innovation that have been interviewed for the World Bank Survey. Note particularly Qatar and Saudi Arabia, which were respectively ranked 11 and 21 over 142 countries. However, this indicator is analytically very weak as it depends on subjective criteria (opinion of the business executives). Science parks have been developed in Maghreb, mainly in Tunisia and Morocco. For Tunisia, it has been a systematic policy to promote technopoles (or technoparks). In Morocco, this has been a very recent move after some difficulties in setting-up successful technopoles. A first appraisal of this policy for Morocco and Tunisia concludes that it is rather too early to have conclusive observations (Arvanitis & M'henni, 2009). Nonetheless, undoubtedly, there has been the creation of new companies, in some cases of very successful medium to large companies. Most of these technoparks function as nurseries and incubators as well as technopoles. Lebanon has probably one of the most successful ones of these, called Berytech, which has emerged as a private initiative of the school of engineering of the Saint-Joseph University. (See Box xx)

In 2009, Jordan was in the process of launching El-Hassan Science Park as part of a major science project in Amman, and Egypt was setting up its own Mubarak Science Park (UNESCO, 2010: 256). This later experiment has been extremely slow to come about and will probably need to be revamped in the future (at least one report indicates that the science park does function as a research center but not as a technology park or as a hub of contacts with its environment.

King Abdulaziz City for Science and Technology (KACST) is a most interesting example. KACST is both the Saudi Arabian national science agency and its national laboratories. The science agency function involves science and technology policymaking, data collection, funding of external research, and services such as the patent office. KACST is a real "science city" (or technopole) with three components: research, innovation and service for the public and private sectors. In term of research it has 15 research teams in different disciplines. In terms of innovation, KACST has three programmes concerning industrial property, an incubator and innovation centers, plus a grant system to "Encourage Excellence and Innovation". KACST has a 2011 giant budget of around half billion US$ ($491,713,692), offering research grants for 64

Figure 14: Innovation System Index for 17 Arab Countries



Source: (UNDP & Al Maktoum Foundation, 2009)

researchers/ research teams with ($16 m). It is interesting that only 23% is in basic science while the remaining is in applied science (31% in medicine, 27% in engineering and 16% in agriculture) (KACST, 2012: 105).

KACST understood that it is very important to provide an outlet for research output by subsidizing open access academic referee journals. KACST partnered with Springer to publish eight international journals to foster the development of key applied technologies, providing a forum for the dissemination of research advances and successes from the Kingdom of Saudi Arabia and the world. Their open access journals are: Applied Water Science, Journal of Petroleum Exploration and Production Technology, Applied Petrochemical Research, Applied Nanoscience, Biotech, Materials for Renewable and Sustainable Energy. All these journals have two chief editors: one westerner and other Saudi (Box 4). What is compelling with the model of this Park that it is driven with local expertise, and contrary to what is happened in AUE and Qatar. KACST is like the university of king Abdellah is local institutions. Instead of parachuting foreign branches in their land, Saudi authorities opted for encouraging a model that is driven by local expertise, with the help of regional and international expatriates. However, for social science, things could be different.

Box 4 - Berytech

Berytech was created right at the turn of the 21st century by Saint-Joseph University aimed to be the first technological pole in Lebanon and the region to provide a conducive environment for the creation and development of start-ups, hence taking part in the economic revival of the country, participating in wealth and job creation, and retaining graduates and hi-level skills in Lebanon.

Berytech grew from one technology pole in Mar Roukos in 2001 to another one on Damascus Road in 2007 (co-funded by the EU). It created a first 6M$ venture/seed fund for Lebanese technology startups in 2008. Several entrepreneurial activities were introduced: Incubation Awards, entrepreneurship contests, summer schools & regional academies for entrepreneurs, “from idea to startup” courses to engineers, Micro-Entreprise Acceleration Programs, university roadshows, local & international exhibitions & workshops, Entrepreneurs Forums, startup-weekends, mentoring programs, networking events, lunch-debates, gala dinners, etc etc. to name just a few.

To date, Berytech has housed a repertoire of more than 170 entities, assisted more than 2,000 entrepreneurs in several outreach programs, disbursed more than 350k$ in grants to startups, and invested more than 5M$ in Lebanese technology companies, and was the first in the region to receive the EU accreditation as a Business Innovation Center (EU BIC label in 2006), opening up access to its companies to international networks. In 2012, and with the support of the EU, Berytech launched the Beirut Creative Cluster (BCC) grouping more than 30 leading companies in the MultiMedia industry, and was awarded by the European Secretariat for Cluster Analysis (ESCA) the European Bronze Label for Cluster Management Excellence.

In line with its vision to grow and support a higher number of Startups and SMEs, Berytech will be running a third Business Development Centre in Beirut Digital District initiative (BDD) area, an innovative environment with state-of-the-art infrastructure, in a prime location in DownTown Beirut, which will be officially operational in January 2013. Berytech is looking also at raising a much bigger fund of 20-30M$ in 3rd quarter of 2013, geared to towards creative industries and the region.

More info on http://www.berytech.org

Qatari authorities protected themselves from the conservative political and religious commissars by asking their university to teach the same curriculum as their program in the university headquarter. In a recent interview with the President of Carnegie Mellon University Qatari Branch, he declared that the Qatari authority is responsible for this curriculum. The major issue at stake is to what extent the absence of freedom of expression in these countries will affect this new emerging model. The development of a “space for science” as socio-cognitive blocs can be an extra-terrestrial space of exception, in the sense that the law of city does not necessarily apply to them, so they can have the freedom to be critical of their own society and their cultural scripts, but also connect to society in the sense of responding to their needs.

A first appraisal of the innovation policies in some Arab countries had concluded that measures to promote innovation cannot be evaluated properly because of lack of comparative standards (Arvanitis & M’henni, 2010). Evidence so far is not conclusive. Direct measures to promote innovation through SME-oriented programmes, Technoparks and incubators are easy to measure: even this is not done, in particular because statistics on the productive sectors are not sufficient. What is also appearing after some more than 10 years of systematic efforts in various countries is that policies have usually been short-timed and success is expected to be easy and ready. If this does not happen, the policy impact is very low. Long-term efforts are thus not encouraged. Examples like Berytech incubator in Beirut or the El-Ghazala pole of technology in Tunis are thus quite exceptional since they survived far beyond the usual short-termed experiences. It is interesting to note that Berytech owes its extraordinary longevity and success to the fact that it is an autonomous management experience based on the permanent institutional support of the University (in this case USJ); El-Ghazala, owes a great part of its longevity to the existence of the school of telecommunications, even though the companies that are inside the technopark do not have so strong linkages with the school as might be expected. In both cases, support is not in terms of money but rather in terms of creating an

Box 5.King Abdulaziz City of Science and Technology

KACST has currently over 2500 employees. KACST's main responsibilities can be summarized as follows:

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 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.

institutional background. The two examples, taking place in probably what can be considered the most opposite types of national research and innovation systems; show that the question of the relations of the private and the public, the enterprises and the State, is not a yes/no question. Institutional support goes far beyond financial support and relates to the creation of an ecosystem conductive to technological development.

9. Scientific capital: Universities and researchers

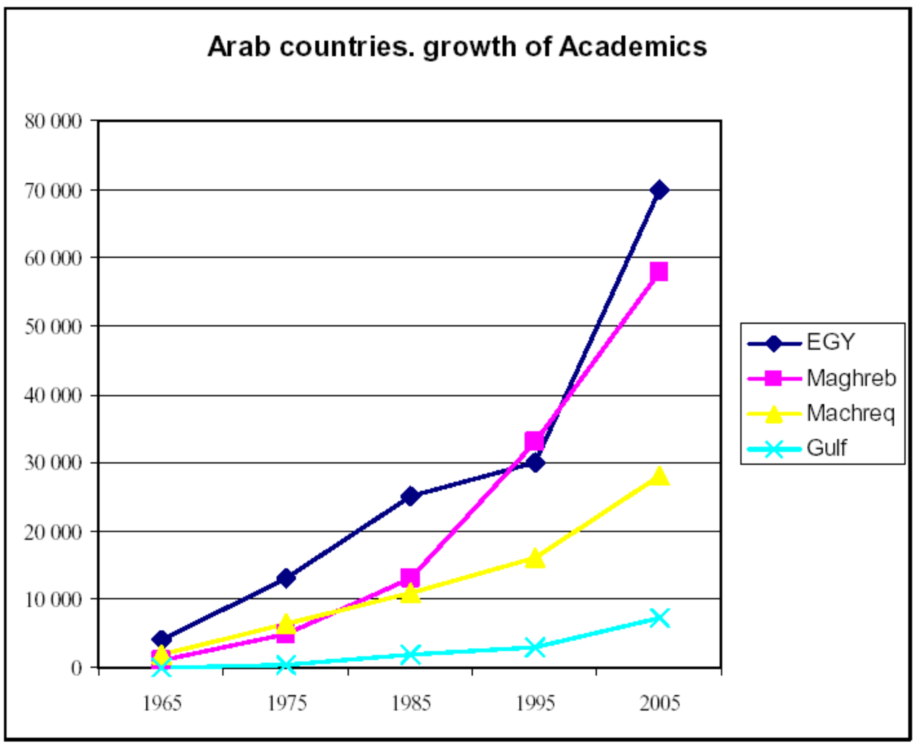
The knowledge production cannot be understood without an enquiry about the researchers doing the research. Algeria, Egypt, and Morocco are now on the path of mass higher education, hence a larger reservoir of teachers doing research. Some countries that lacked a proper university system are also in an ascending path, as is the case of Libya, Syria and Iraq (which in fact had a quite famous educational system before the wars raged the country). The rest develop a national system for everyone but with limited capacity. In addition, in all these countries a new massive actor has appeared : private universities that absorb the elite, or 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 a viable management (incentives, door-to-door search for contracts, coordination of fundamental and applied research, liaison with other performers) that helps research be grounded 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 (Mouton and Waast 2009).

Table 17 summarizes some of the indicators available concerning the research human potential. Preparing researchers starts from investing in the higher education. This is shown with state budget, in this regard, ranging from 0.8% from the GDP for Egypt and Algeria to

1.2% for Tunisia. However investment is larger as this does not include the private and non-for-profit universities. In fact, only few of this latter play the significant role for research: the American University of Beirut (AUB) and St Joseph (USJ) in Lebanon; Université des Sciences et de la Technologie Houari Boumediène (USTHB) in Algiers.

All higher education institutions produce a huge number of students: approximately 1.8 million in Egypt and ¾ m. in Saudi Arabia, from which respectively 102,000 and 11,000 are graduate students.[24] Figure 15 shows us the development of the number of faculty in Arab university, which has steadily increasing since 1965. Note however that 1995 is a starting of more fleshing increase for the Gulf and Egypt.

Figure 15: Growth of Academics in Arab Countries (1965-2005)



Source: Mouton and Waast.

[24] In the Arab world, the number of students 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 2185, according to the UIS (UNESCO, 2010:68).

However, it is very difficult to draw an equation between the number of graduates or faculty and number of researchers, as we know many of them do not go into research. A minor percentage of them would possess visible knowledge in the international arena, through their publication in referee journals counted in Web of Science or Scopus. The reason is not only related to language (the fact they don't publish in English language) but also the fact that

Table 17 a: Distribution of countries according to GDP/capita & no. of researchers/million inhabitants

	Expenditures in higher education					Students				
Country	in million US$	% of GDP (2008)	% of government budget (2007)	per student (2007)	number of universities (2006)	number of students (2007)	MSc Students (2006) in Science & Technology	MA Students (2006) in Total social sciences and humanities	Ph D students (2006)in Science & Technology	Ph D students (2006) in Total 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				

many Arab universities are not research universities, even if it is written in their bylaws. From 33,481 researchers in Egypt, statistics suggest that 13,941 estimates on full-time equivalents (FTE), but indeed only half of them will publish in referee journals. The FET in Egypt

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 referee journals (2010)
Egypt	33,481	420	13,941	617	7,669
Iraq					499
Syria					75
Libya	390	61			24
Algeria	5764	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	

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 (UNDP, 2009:190). In a university like the American University of Beirut, which is a university where research is a rather frequent activity, our survey shows that around 40% of academics' time is spent in research. This is an average of two publications yearly for each FTE in AUB (See Table 18 for comparison see other universities in Lebanon. Note how this is different in the Lebanese University, which is a public university).

A recent study that relies primarily on government data from ten Arab countries (Nabil '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 as low as between 14 and 4 per cent in Oman, Yemen, and Mauritania (UNDP, 2009: 191).[25]

Beyond these numbers, where are these researchers located? While in social sciences they are located between the NGO-status research centers and universities, in other sciences they are mainly in universities or public research centers[26] (or state-sponsored science parks). Research has shown that the bulk of S&T research in the Arab world is carried out within the higher

[25] If we take the number of faculty as indicator, we find that 30% of 125 000 university faculty members in Arab countries are women. Some researchers have put this figure at over 170 000 (Waast et al., 2008), but this could be due to the inclusion of faculty teaching at more than one university, meaning they would be counted more than once. (UNESCO, 2010:71).

[26] These centers 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 (nationally)

education system, even in Egypt where this represents 65% of R&D (IDSC, 2007, UNESCO, 2010: 257) In 2008 Arab countries spent $16.26 Billion on higher education for 6.62 Million students (Mrad, 2011).

Scientists or a scientific community?

An issue raised by many researchers (Mouton and Waast 2009) 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 be a good management tool however: it has been well documented in "intermediary" countries (for instance in Morocco or Jordan) that even in leading establishments, there are no more than a score of successful research niches; and within each of these no more than ten very active researchers, and a score of more episodic contributors (Kleiche and Waast, 2008). These persons very often do not collaborate with people outside 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 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. However we are not sure how important the concept is. Its origin is atomic energy and corresponds to the idea that there is a minimum size to be respected. 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 newly (after the 2nd WW) founded fields such as nuclear & high-energy physics. Nobody has ever proven which is the 'right' critical mass that will trigger 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 of the research community. Of course, numbers count, and having 60 researchers in an area is certainly better than having only one or two. But research can be the result of collaborations and these could very well be maintained by 'low-level' activity.

strategic areas and are commissioned to generate more practical outcomes. See a report of Issam Fares Institute (IFI 2011).

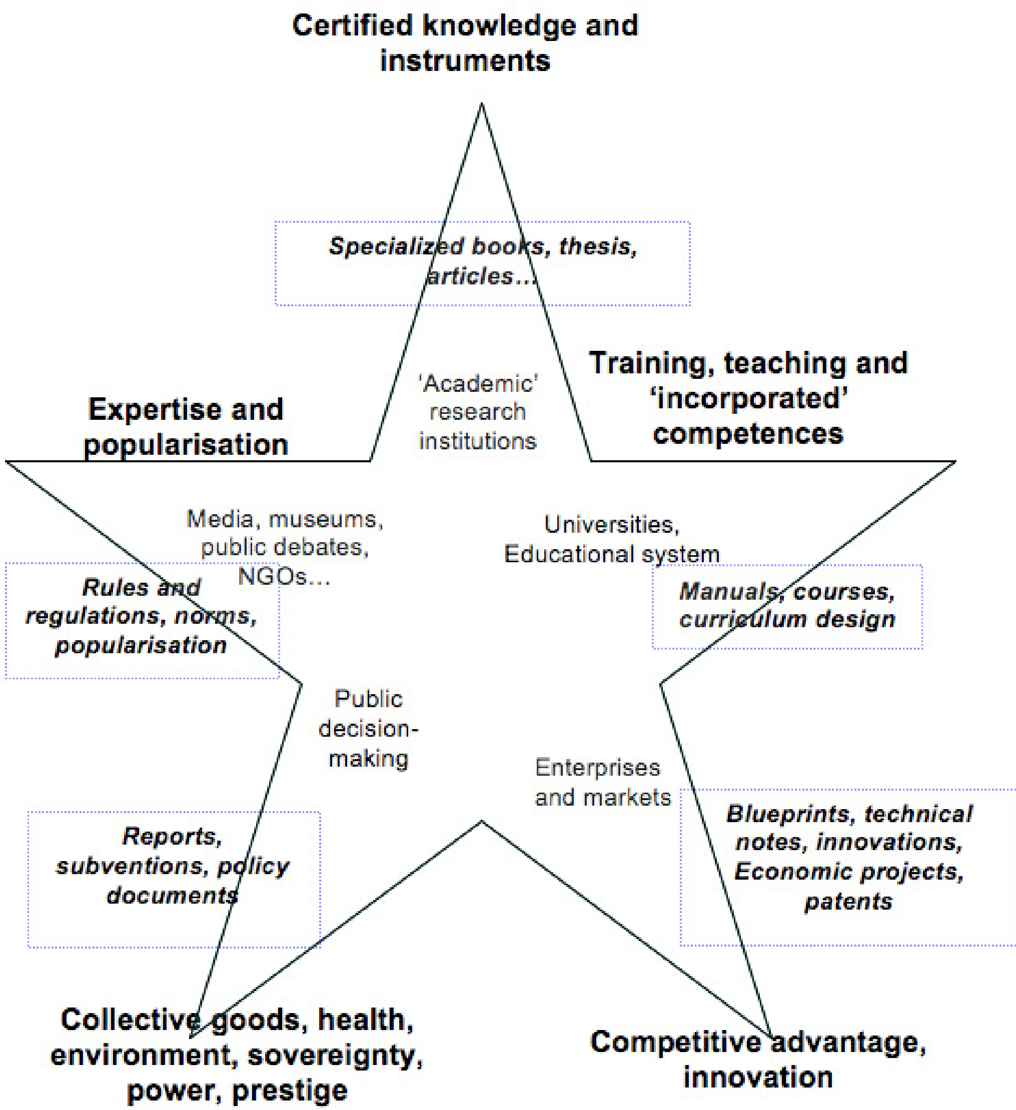
Some aspects that seem important are the structuring if the scientific community as such (Gaillard, Krishna and Waast 1997), which in turn favours the creation of strong research teams (an institutionalization process that can be accelerated only to the extent that research teams are consolidated) (Vessuri 2004). What seems to be decisive is not so much the number

Table 18: Lebanon's Research Performers - by decreasing order of scientific publications

University	Publica-tions 2000-2003[1]	R&D personnel FTE[2]	Expendi-tures on R&D [2]	Total teaching Staff [3]	Total students[3]	Year of foundation
American University of Beirut (AUB)	**607**	100	17,8	813	7000	1866
Lebanese University (UL)	**162**	150	11,4	4400	71000	1953
Saint Joseph University (USJ)	**160**	90	8,0	1830	9800	1875
Beirut Univ Hospital	**63**	?				
Lebanese American University (LAU)	**42**	10	Together: 6,0	180	4500	1924
Balamand University (BU)	**22**	20		940	2800	1988
Beirut Arab University (BAU)	**15**	10		670	13500	1960
34 other universities	**26**	40		4900	39000	3 out of 4 since 1996
CNRS: 4 Research Centres	**15**	50	5,5			
LARI (Agric Res.)	Together: **10**	55	5,2			
IRI (Indus Res.)		10	0,3			
5 Other Res. Centres		3				

of researchers but rather the connections of the research activity with non-research activities, be they economic or other –R. Waast (2006) has called this a ‘pact’ between scientists and society. It is necessary here to understand that the researchers have multiple functions. They produce academic work and scholarly work that is visible through their production in scientific journals. But they have more functions. Figure 16 (The 'Rose of Winds' of Research) indicates schematically most of these functions: they go from the academic and 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-fit-for-all scheme of support to research.

Figure 16: The 'Rose of Winds' of Research

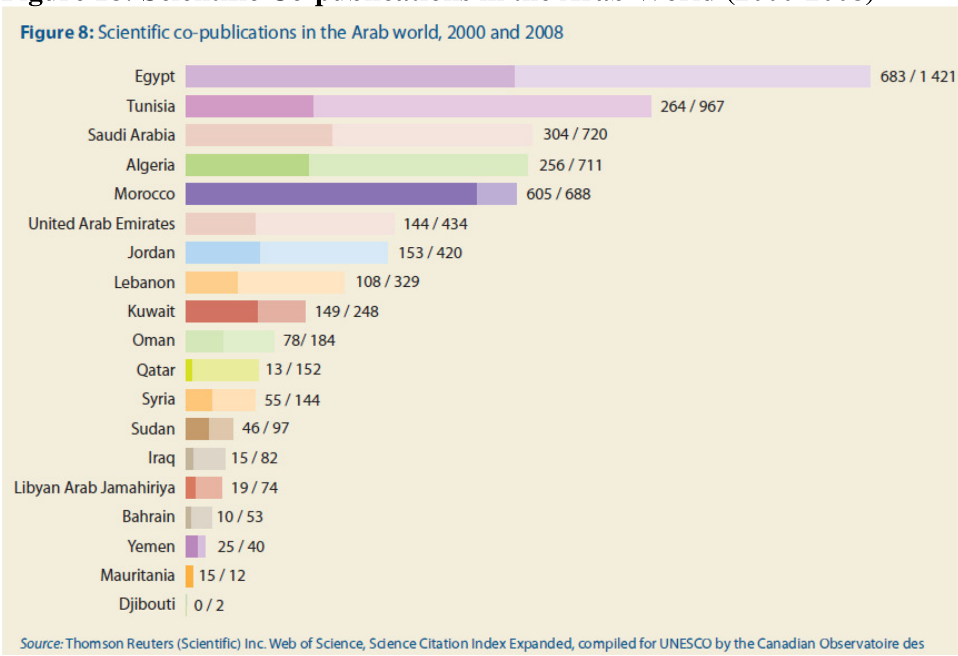


Source: Callon, M., Larédo, P., & Mustar, P. (Eds.). (1997). *The strategic management of research and technology. The evaluation of research programmes.* Paris: Economica.

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. It equally provides some researchers with an insight in other fields that pertain to their research.

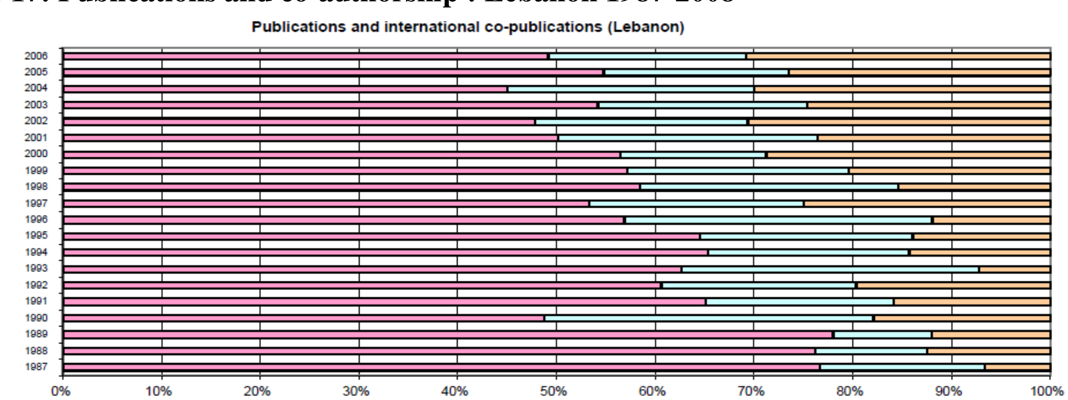
Figure 18: Scientific Co-publications in the Arab World (2000-2008)



In their paper entitled "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 EU science policies and of bibliometric analysis." They find that "the increase 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" (Hick & Katz, p. 394). These drivers for international collaboration have been confirmed by a recent review of topics on the theme used as background by the European Commission (Boekholt et alii, 2009).

Bibliometric studies carried out in recent years are all unanimous in finding that there has

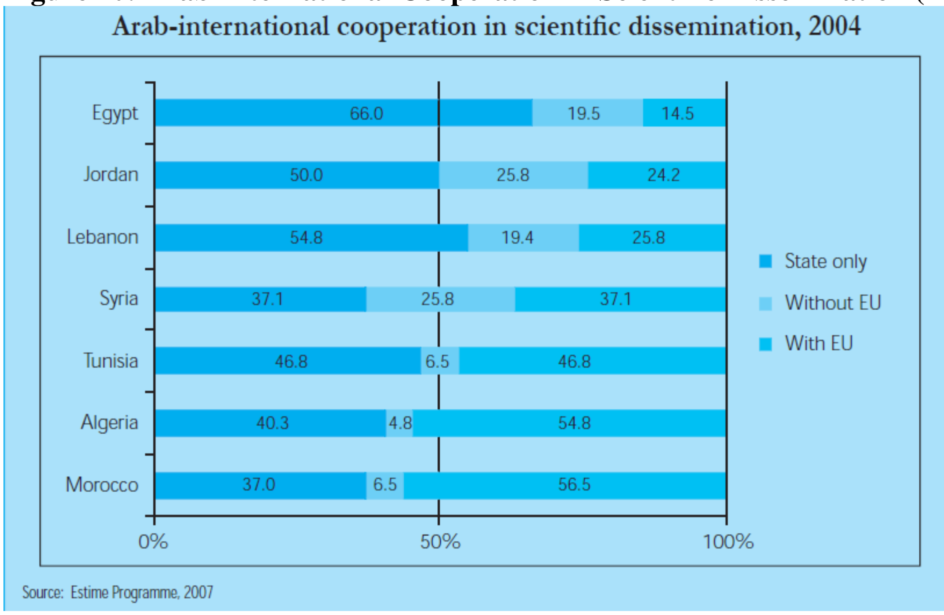
Figure 17: Publications and co-authorship : Lebanon 1987-2008



	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 been a sharp increase in scientific collaborations, and more particularly in international collaborations. Increasingly, Arab scholarship is done in cooperation with scholars abroad, as we see in Figure 17 that points out 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% in 1987 to 55% in 2006) but also it has been progressively re-orienting toward more collaborations with European partners. We notice that EU is the major region of cooperation, thanks to its funding system (Figure 20), and specifically with France for Tunisia and Lebanon (Table 19: Arab-International Cooperation

Figure 20: Arab-International Cooperation in Scientific Dissemination (2004)

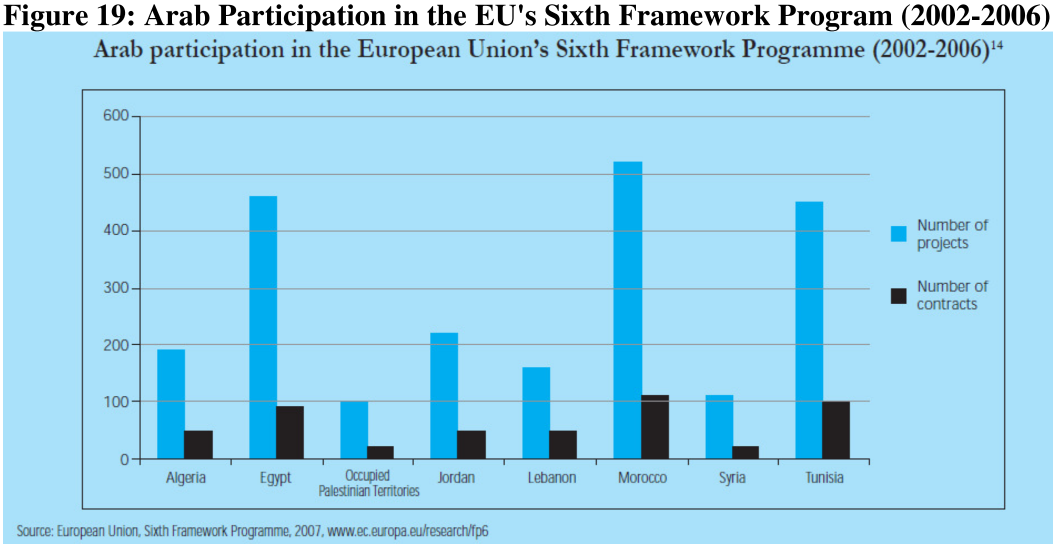


Source: UNDP & Al Maktoum Foundation, 2009

in Scientific Publishing).

We see that the United States is an important partner for Egypt, Jordan, and in Lebanon, particularly for AUB (which count for more than a quarter of Lebanon's publications) and LAU. France has been a privileged partner for Morocco, Algeria and to a lesser extent Tunisia. In general, France, in the "Mediterranean region" (countries around the basin), is the

Figure 19: Arab Participation in the EU's Sixth Framework Program (2002-2006)



Sources: (UNDP & Al Maktoum Foundation, 2009:193) main scientific funder for international projects through bilateral programmes (Arvanitis, 2012).

Also, co-authorship with the EU has grown in all countries (even those ‘preferring’ usually the USA), and this is directly due to the effort put by the EU to open its programmes systematically to non-EU partners (see Arvanitis, 2012).

Finally, it is important to note that the hierarchy of countries of partnership are not only sensible to policy, but is changing rapidly from what it used to be some ten years ago. The appearance of Saudi Arabia, Italy and Spain are frequent countries of co-authors is remarkable. It relates to a proactive policy of international cooperation on art of the authorities of these countries as much as to the growth of the research activity. Spain, for example, has known a massive growth of 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 of its participation to international programmes with neighbouring countries in areas of its competence (cultural heritage, archaeology, agricultural sciences, food sciences). The more ‘traditional’ players (France and the USA) have seen their relative share diminish but in a context of growing collaborations and co-authored publications.

Table 19: Arab-International Cooperation in Scientific Publishing

Arab-international cooperation in scientific publishing

	Tunisia		Egypt		Lebanon	
Rank	Country	%	Country	%	Country	%
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	..

Source: Thomson Reuters and the Science and Technology Observatory (Observatoire des Sciences et Technologie - OST, Quebec, Canada), 2007

Inter-Arab cooperation

Our research on research practice in AUB, Lebanese University, and USJ shows how limited the Arab inter-regional cooperation is (Hanafi, Arvanitis and Baer forthcoming). This concurs with the work of Antoine Zahlan (2012: 193) who points out that there has been some 1000 research papers published on aquifers by scientists, but only few scientists collaborate to enable them to bring their expertise to serve the entire region. Even the collaboration is week within the same country. Our survey in Lebanon among the AUB faculty found that interviewees at AUB collaborate both with other faculty members at AUB, as well as with other researchers abroad, notably through contacts formed during PhD and postdoctoral years abroad. However, very few had ever collaborated with other researchers in Lebanon outside of AUB. A professor in the faculty of medicine mentioned that “scientists in the Arab world do not communicate with one another- they tend to remain in the same field, 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 for that matter with that of their European, Turkish or Israeli counterparts. They all, communicate and evolve, an they are all lacking research time! That is probably their main difference with Europeans: lack of time to do research (Gaillard et al. forthcoming).

In the Gulf area, we notice a recent increase in co-publications within the Gulf region. As we see in

Table 20 the UAE and Saudi Arabia have the most co-publications, although figures are very (23 and 19 publications respectively).

Table 20: 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: 162

10. Brain drain and scientific diasporas

Brain drain is a major concern today. Figures released by the Organisation for Economic Co-operation and Development (OECD) show that around one million of highly qualified persons of Arab origin reside in the OECD countries and this number corresponds to 10% of the highly qualified population in the Arab World, and 20% of the population in the Maghreb countries (Wahishi, 2010: 7).[27] In Table 21, we see the number of Arab expatriates and percentage of highly skilled expatriates by country of birth.

Mouton and Waast (2009) give us more details from the USA as the National Science Foundation in 2000 reveal that there are thousands of Arab scientists and engineers living in the USA: 12 500 Egyptians, 11 500 Lebanese, 5 000 Syrians, 4 000 Jordanians and 2 500

[27] 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%) than for the native-born (19.1%) (Dumont and Lemaître 2005). Tt 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 1981; Inkster 1991)

Palestinians. Scientists from Morocco and Tunisia on the other hand, tend to head for Europe (Waast et al., 2008)(UNESCO, 2010:271). As you see from Table 21, the number of researchers in Lebanon is slightly larger than the number of researchers employed in R&D in USA. This shows the importance of the phenomenon of brain drain.

Table 21: Total number of Arab expatriates and percentage of highly skilled expatriates by country of birth

Country	Total number of expatriates	*of which:* highly skilled %
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

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 its major exports, possibly equating oil and gas in value. The little data available sustain the 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 Arabs, the Arab world 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 (Zahlan, 2004; UNDP, 2009:208). Over 200,000 PhD holders (80% of Arab PhD) which are unable to connect with the local economy emigrate (Mrad, 2011). The expert report of IRD on "Scientific diasporas" has gathered all the data and reports on this topic (as of 2003), among which the exceptional study of Jean Johnson of which we extracted some indicators along with data of the ESTIME project (Table 21)). Estimates of the number of researchers in some Arab countries seem close to the number of researchers originating from this country living in the US (e.g. Lebanon). In other words the scientific potential is out of the country. Every time a newspaper article re-discovers this reality is immediately making responsible the country's authorities for their incompetence ! But the is a need to better understand the reasons of the scientific diaspora in relation to the emigration in general out of the countries.

The situation is very different in the Maghreb and the rest of the Arab World. According to the NSF, very few scientists from the Maghreb are established in the USA. But scientists from the Maghreb are nevertheless heading for Europe (mainly France), and recently for Canada. A bibliometric study in the social sciences has just proved that 60 per cent of the 100 most productive social scientists from Algeria were now living and employed abroad (50 per cent of the 200 most productive, authoring more than 1/3 of the production in the last 25 years). The proportion of Moroccan authors living abroad is much lower, 15 per cent of the 100 most productive (Rossi and Waast, 2008). 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; and 90 per cent of scholarship holders never came back from abroad in 1995. To this should be added the well-known exodus of "highly qualified persons" (among whom a number of leading researchers and academics) during the Civil War of the 1990s (Khelfaoui, 2004). However, Hocine Labdelaoui (2010) argues that because of many "push" factors in France and an improvement of the situation in Algeria has convinced many Algerian faculty and researchers to return to their country.

Table 22: Brain Drain from the Middle-East in the USA: Number of scientists and engineers established in the USA, 2000

	Egypt	Lebanon	Jordan	Syria	Palestine	Kuwait	Maghreb
Established in the USA	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 alii (2003). * ESTIME www.estime.ird.fr

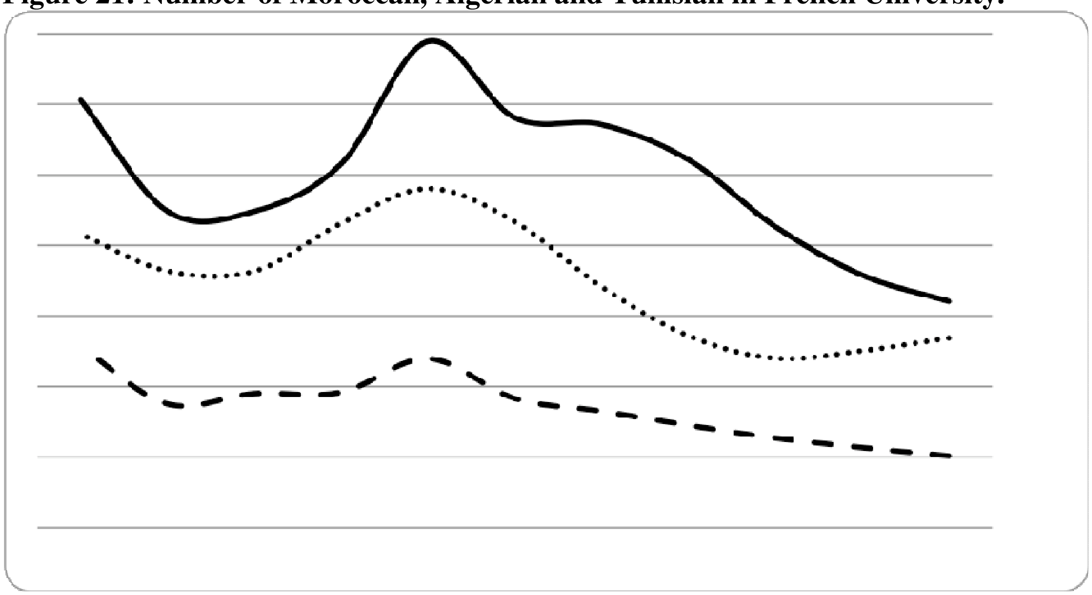
There is a range of opinions about brain drain. In many countries, the official point of view is that emigrants are despicable traitors, who prefer their own material well-being to their homeland's interests. Added to that is the claim that there is a deliberate "pirating of brains" by the wealthiest countries, at the expense of the poor countries which bore the costs of their education (Mouton and Waast, 2009).

There are elements of truth in these arguments (especially the second one); but intellectuals are not the only ones fleeing some countries, and there is no reason for them to remain the hostages of governments that do not care (or know how) to use their talents. Moreover, the argument seems to indicate the idea that highly-skilled individuals because of their training somehow belong, not only to their Nation but also to their State. The view draws back to the concept of State-driven development which has been the predominant model nurtured by post-war experience (Gaillard, Krishna & Waast, 1997; Amsden 2001). Some recent studies have convincingly proven that most intellectuals' attitudes depend on the national science policies, and on the movements of international industry. The North African case has been well-documented: as far as the profession is decently treated (status, income, and no tremendous claims) and scientific life can go on, brain drain is much lower (as in Algeria or Morocco) and most students come back home after completing a doctoral degree abroad. They may be giving-up lucrative careers in the emigration countries, but prefer (managerial) positions in their home environment (Gérard et al. 2008).

Another feature is noteworthy: ever since some multinational firms decided to invest in Morocco about 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 engineers it graduates; it has been partially able to respond to this objective. A part of this success relates to the quality of its higher education system as far as 'elite' engineering schools are concerned (modelled on the example of French 'Grandes écoles'), which attracted the interest of said firms in the first place; the same is true in Tunisia. The low cost of labour concerning the management positions combines, in effect, with the quality of the training.

Another opinion is that there is no real brain drain, but rather a natural flow of scientists to the

Figure 21: Number of Moroccan, Algerian and Tunisian in French University.



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

best places in which to exercise their talents. The "marketplace" of knowledge and know-how will organize 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 is being emerging since the late eighties with the loss of control from the State over their own training-qua-employment system. It should be underlined that some countries had very restrictive systems of scholarships for their most talented young student, that permitted them to be trained abroad in exchange of an employment, usually in the public sector, on their return. Such has been the case for example in Syria, and returnees that 'escaped' their return obligation had to pay fines or worse had to confront menaces from the security services. Then the impact of the international mobility of the highly skilled is thus diverse. Dumont and Lemaître (2005) argue that the largest developing countries seem not to be significantly affected and indeed may benefit from indirect effects associated with this mobility while some of the smallest countries, especially in the Caribbean and in Africa, face significant “emigration rates” of their elites.

To overcome brain drain, the work conditions for researchers should be improved (in terms of having conducive environment to research and increase their salary). 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 reverse: the top-down initiatives in higher education, the temporary use of the diaspora expertise and the network with the diaspora.

Top-down initiatives in higher education

Three regional initiatives exemplify recent top-down initiatives in higher education: Qatar’s Education City (see Box 6); 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 like Algeria and Egypt, which have been hit by an exodus of talent (UNESCO, 2010: 71).

Box 6: Qatar's Education City: an example in “branding” strategy
Brading strategy consists in inviting a famous foreign University/Institution to create a branch locally and use its name in the country. Qatar Foundation has funded in this way the Qatar Education City which included branches of eight selected elite international universities, delivering “world-class programs chosen to ensure Qatar is equipped with essential skills and specialties”: 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, HEC Paris, University College London Qatar. The city is also home to educational institutions for children and teens, and research institutions (i.e., RAND-Qatar Policy Institute, Qatar Science & Technology Park, Qatar National Research Fund). Education City is also the home of the Qatar Music Academy/Qatar Symphony Orchestra.

Some Gulf countries are now offering excellent facilities to international enterprises and universities, in order to attract and territorialize them (called also “branding strategy” – see box 4). For instance the University of King Abdel Aziz attracted 20 scientists from the UK in 2012 by providing each one million dollars for their research. So far, however, it has not found niches of excellence. This top-down imitative can be state initiatives or private institutions one. In this 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 in 2009 survey in US among Lebanese doctors practicing in USA,[28] out of 286 doctors surveyed, 61% were willing to relocate to Lebanon but only a third were willing to relocate to the Arab gulf. A little more than half of them were willing to relocate to Lebanon as a base for clinical missions to the gulf. These findings suggest that there is a possibility of making Lebanon a regional 'academic hub' by recruiting Lebanese medical graduates practicing abroad is feasible (Akl et al. 2012). It is also worth mentioning that one of the most successful technological centers, Berytech, was initially conceived by the school

[28] Of a sample of 500 physicians researchers attempted to contact, 286 participated in the survey.

of engineering of Saint-Joseph University as a way to repatriate young professionals that were fleeing out of the country.

"Brain gain": the temporary use of the diaspora expertise

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 world, especially in the post Arab Spring Era. In this case, is it possible for a voluntary facilitator role to be assumed by the Arab governments or the international community to harness this group and facilitate the transmission of expertise by the migrant community towards the homeland? As Meyer et al. (1999) 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 scientific, technological and cultural programs at home (a diaspora option). Let us present the Palestinian case and to see what lesson can be learned for the Arab world.

These two policies have both been employed in the Palestinian Territories: in the former, through a UNDP program, which encourages repatriation, called TOKTEN (The Transfer of Knowledge Through Expatriate Nationals),[29] and in the latter through an internet-based network called PALESTA (Palestinian Scientists and Technologists Abroad).

The TOKTEN concept has been an interesting mechanism for tapping national expatriate human resources and mobilizing them to undertake short-term consultancies in their countries of origin. The United Nations Development Program (UNDP), which implemented TOKTEN in order to utilize the expertise of expatriate nationals, demonstrated that specialists (who had migrated to other countries and achieved professional success aboard) were enthusiastic about providing short-term technical assistance to their country of origin. Often these individuals returned and settled permanently. This program has been applied over the past 22 years in some 30 different countries, resulting in the application of thousands of technical assistance missions by expatriate professionals to their home country (UNDP, 1996). One of the main catalysts in the creation of the TOKTEN program was the growing necessity of counteracting the so-called 'brain drain' from developing countries to the first world. The program has created databases of highly trained and experienced expatriate experts and in the 1990's assigned more than 400 of them per annum on a volunteer[30] basis to their countries of origin for periods ranging from one to six months. TOKTEN volunteers have served in governmental, public and private sector, academic and NGO sector capacities.

The TOKTEN program in the Palestinian Territories is considered one of the most successful with more than 178 Palestinian experts who have contributed to Palestinian development under the TOKTEN modality. Palestinian TOKTEN consultants, for example, have helped reform the treatment of kidney disease in Palestinian Territories and have guided the development of macro-economic frameworks and planning. TOKTEN skills also have 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, on cultural preservation including the Bethlehem 2000 project. The lack of expertise in some sectors where people have volunteered under TOKTEN has generated some genuine success stories in Palestine, such as the construction and opening of the

[29] For TOKTEN program see (Hanafi, 2001)

[30] In the Palestinian Territories, TOKTEN consultants receive $2,000 US Dollars, if junior, and $3,000, if senior in addition to paid travel expenses and miscellaneous expenditures.

international airport in Gaza. In this case, 9 TOKTEN consultants have stayed on and presently constitute the backbone of the airport's operations (UNDP, 1999: 1-2).

However, the success of the TOKTEN program should not be measured solely by increasing demand and efficacy; the experience provided returnee experts with a first-hand taste of life in the homeland and encouraged them to settle (within the limits of Israeli immigration control) in the long term. In fact, some 34 of 160 TOKTEN experts, about a fifth of the total, continued living in the Palestinian Territories after the expiration of their TOKTEN assignment. The TOKTEN returnees have come mainly from Jordan and the US, two countries whose Palestinian community have kept close ties with family networks in the West Bank and Gaza. Such a percentage should be considered quite high for a country like Palestine currently experiencing a difficult political and economic situation. In Lebanon, a country in which expatriates do not experience problems in acquiring residency, only 6 of 36, or one sixth, resettled after their mission (Ghattas, 1999).

Finally, the TOKTEN program raises questions concerning the nation-state framework's capacity to deal with issues of brain drain. In an increasingly globalized skill and labor market developing countries are rarely able to compete with developed countries which offer far higher wages. In such a case, TOKTEN can be considered a mechanism by which recipient countries (usually western) compensate countries of origin. In terms of the Palestinian context, such a mechanism can prove vital in a current political and economic situation that will not encourage (and actually bars) the homecoming of refugees and diasporic people and where the outflow of skilled individuals will most likely continue.

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 center. PALESTA (Palestinian Scientists and Technologists Abroad), an internet-based network, has the objective of harnessing the scientific and technological knowledge of Palestinian expatriate professionals for the benefit of development efforts in Palestine. There are two other 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) (Meyer, 1999).

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

Despite PALESTA's ambitious objectives, however, current analysis of this network demonstrates mixed results.[31]

The experience of PALESTA demonstrates an increasing importance of Palestinian professional diaspora networks. PALESTA's electronic discussion list has had a positive effect in providing space and form for a new experience of community and a rewarding in-

[31] This assessment is based on findings of an evaluation study conducted by Sari Hanafi.

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 another such network, allows mutual identification for actors and allows inferences to be made concerning their associations. (Meyer et al., 1999: 7) However, the virtual community has its limits. A critical examination reveals a tendency, as Wilson (1997: 158) suggests, of "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." Though PALESTA members number more than a thousand, data suggests that only 20% 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 in the electronic exchange with very few forms of physical contact or concrete projects launched via the network.

This kind of argument is also done by Gaillard & Gaillard (2003) who pointed 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."

11. Three socio-cognitive challenges facing research and innovation

In conclusion we would like to point out three major elements that affect deeply research in the Arab World and which will necessarily be part of any substantial change in the region: the model of development the Arab world wants to adopt, the trust it will put in science, and the social environment, conducive to the development of science. These are not aspects that can be changed by a single policy but rather they will be modified as part of the policy recommendations that we will revise in the next section.

Models of development in the Arab world

Most Arab countries rely on income from natural resources (for instance the oil economies, or Phosphate for Jordan and Morocco), or from the development of services (tourism in Lebanon and Tunisia) and remittances of the emigrates (case of Lebanon but also in Maghreb). These income sources do not to rely on science and research. The commitment to research should b, in this case, based on a certain vision of the future. More generally, science was a sort of prestigious cultural activity. The universities were maintained with a view that they serve an elite-making purpose, invite topflight teachers, and support the research for the nefit of those already hired by universities for their own career and the prestige of sponsors (as in some Gulf countries until recently), but the commitment is unclear. Moreover it does not take into account the formidable pressure on higher education and research as these become necessary activities in the obtaining competitive advantages.

There has been, historically, a strong link between the development of science and industrialization. The nationalist governments that tried to develop import substitution, even when they failed in that plan, generally established a science base which remains a national asset for the country (see Egypt for some time and Maghreb countries). Industrialization may not be the same objective for all, in particular service economies. But productive activities, in ITC like in traditional industries need a technological base today that is much more important than 50 years ago: the science that goes in equipments and know-how is relying on more skilled labour an higher degrees of integration of the productive and technological activities. Using a productive process can no more be a complete 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 level (or nanolevel…). Even simple automatization of productive tasks relies on sophisticated knowledge. And the management of natural resources, for food, agriculture, water resources and the like, need more knowledge input. Thus even if the older "industrialization" project seems out of date, and the "knowledge economy fancier, one should recall the "productive model" as being one of reference: countries without a local productive base will be swept away in a global competition based on high skilled knowledge and 'dynamic' competitive advantages. This competition is, until now, deeply unequal, more than the older industrialization model ever was. The knowledge gap will widen if there is no local productive activities and if all local skills fly away seeking better employment and living conditions.

It must be stressed that the (re)building of a science base is slower and more difficult than its demise, and that the tribulations of a "to and fro" strategy in support of science leave long-lasting scars. However under the hammer of the market, the "national" mode of knowledge production fell into disgrace, and more linkages were established with the market economy. This shift, more often than not, led to a withdrawal of state support, and sometimes to the disparaging of local scientists as parasites, "cultural curiosities", but not active members of the national productive project of a nation. Revindicating a space for research is one among the necessary steps toward a productive development model.

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 (Khelfaoui, 2000: 5)

There must clearly be some pact (at least an implicit one) between science and society. However, As Jean-Jacques Salomon suggested in this exergue that the discourse on science is easy to be formulated and legitimized but not the *practice* of research, due to the lack of professionalization of scientific community and its institutional acreage.

For a long time, since the Second World War, the opinion has been that the development of science benefited the people and generated new, salutary technologies. It was among the main results of the Mouton & Waast *Comparative Study on National Research System*: countries with a reasonably strong base considered science as a source of progress for humankind; its support was the duty of the state; and its results were considered public goods. This applied to the developing world, too, and free of colonization, its governments entered into the building of higher education and research centers, with the support of international cooperation and funding and with greater or lesser ambitions (enlightening minds, or harvesting rapid, useful results). Scientists organized professionally, but the promises seemed a long time in coming. As the reference to a market economy became the new norm, well-being was no longer sought from the state but from enterprises and the market, and curiously this progress was not specially favourable to science, too much liked to its Second World War heritage of "science of the state". Well-being was thus supposed to come rather 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 by developing a sound innovation system. Even if scientific research does not seem to be directly translatable in commercial products it increases the capacity of the country to promote innovation. The demand for research, coming either from the public sector and –seldom– from the private sector is usually not only low but also directed preferably to "applied" objects; moreover, there is some disdain for basic sciences and fundamental research and it hides an uncomfortable attitude toward the more advanced nations. But "applied research", to put it differently, is also the product of very fundamental research. Useful science is the product of science that is trusted.

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 the career patterns, but also a larger social environment. The job environment of researchers should be scrutinized with some care: trust comes from the scientists' employer (often the government or public "autonomous" universities). Since most researchers are also in universities, and since universities have been first geared toward teaching, research was not part of the initial component of their job description. The "terms of reference" of job of a university professor until very recently didn't include research. The latter was a promotion activity, not very well defined, but that could serve the purpose of promotion. Career patterns were (and still are) influenced by the promotion system and it would be advisable to include them as part of the research policies of universities, in the larger pattern of the role of research.

Another component of the social environment refers to the social values and political and social context; it refers to the space given to science in thinking about the future. Some nations have traditionally held science in high regard but were not giving researchers the means or social role corresponding to this more general aspiration. Modernization has been blurred in great part because of this distance between the professed glorification of science and the near to infamous condition of research practice.

Understanding the value of knowledge is also part of this double recognition as an aspiration, a part of the nation building, and the practical matter. Political power or material wealth may supersede all other aspirations. Religious beliefs, values related to aristocratic ancestry or to the family may also override all other considerations. All these may well interfere with a commitment to science and its standards. In come countries, ourselves, we have documented example of self-censorship for religious or political reasons, as well as because of family duties superseding professional obligations. In many places, this may reach 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 no science will prosper.

11. Recommendations: A vision of the future

According to Zahlan (2012), for the first time Arabs were really aware of their chronic state of under development in science and technology, thanks to 2004 UNDP reports, and the Arab Knowledge Report (2009) of Al Maktoum foundation somehow pursued further the aspirations of the three first reports. This observation should be accompanied by another one: in every Arab country, scientists and policy-makers (very often former scientists themselves) in charge of science have been trying very hard in the last ten years to create a transformation of their research systems. They did this by earning a political ground inside their administrations and institutions pace after pace at a very slow rate and securing, finally, very little and fragile commitments. Governments usually discovered at their own expenses that when the trick worked, when scientists began working, all sorts of unpredicted benefits where rushing in. We could write a chapter in each country about how this came about, based on our own experience and that of many interviewed scientists. It would show that the reasons of this re-enactment of science policy in the last years differ grandly in one or another country. They do not relate to the particular problem of lack of sovereignty and lack of political prestige. In all cases it was a movement from the institutions, universities, schools, research institutes, and some policy-making people securing resources for research. In the process, the astonished governments discovered that science is not any more a fashionable, cultural and entertaining "social" activity. They discovered it is now professionalized worldwide and, more importantly, quite expensive. Interest in research by the specific policy-makers is thus not so much related to the national pride as to the defence of competitive advantage. Moreover, 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 may be the prospect of a spectacular increase of the level of spending. Is the region ready for such a major overhaul?

In this report we will draw some recommendation and a sort of a vision for future, taking into account some challenges to be faced.

Fixing the cycle between research, university and society

Arab countries have small patenting figures. 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. But this is only a small part of the more general issue of the relation of research with the economy and society. As we have mentioned earlier when talking of the various functions of research, there is an insufficient appraisal of all the activities that are not directly linked to production of scientific articles and books. More generally there has been a broken cycle between research, university and the society. It expresses differently in different domains of economic, political and social life.

One of the most important aspects has been the working conditions of researchers in their institutions. Since most of the researchers in Arab countries belong to Universities, this relates very much to the way universities are supporting research. There will be no real progress if universities do not promote actively research in their own teams, within their own departments, and faculties. Action here will necessarily be related to creating, internally funding opportunities and not only to individuals but to team work; promote the use of external funding and help provide administrative support for the development of research activities when funding is given to specific projects. In many universities in Morocco we have been told that the use of external funding money by the actual research teams that are funded is close to impossible! This is true for any kind of research, be it in basic sciences, applied and engineering sciences, or else.

Also, in many universities, the sweeping majority of faculty are absorbed by heavy load of teaching and capacity building for the institution where they work. One faculty at Aleppo university point out this is clearly: "I stayed 12 years in Japan and I published 12 articles. I came back to Aleppo, I have not produced any article in these 12 years since my returning [..] I have done a lot of things about teaching, capacity building and obtaining projects for the university". Faculty who are capable to produce good research are those who receive support from their own institutions. In the absence of this institutional support, research will always be a marginal activity.

Moreover, research has been too narrowly related to the individual promotion of professors. 'Research' has a distorted sense in this case since it only relates to the reception by the colleagues and the administration of the university and only for a specific person. On the contrary, research should be promoted as part of a collective endeavour that has shared activities common working plans.

Another important aspect that relates to the institutional capability to support research is the existence of post-doctorate fellowship and grants are important and they are rare in the Arab world. For instance, among those who benefited from post-doctorate among American University of Beirut faculty are only 3 over 26. Others have it outside the region. Also, in the largest university in Lebanon, the Lebanese university, there is no post-doc system, as is also the case in many universities.

Many Arab universities give grants for research only to full professors, ie. at age over 50. This was evidenced by one professor in Cairo University in the biological sciences who once declared in an fieldwork interview that “now that I am a fill professor, I can begin research!”. He was close to sixty years old and evidently originality will not be the major feature of any research undertaken at that age. Young faculty do not get easy support and there is a lot of room to increase the support to young faculty by promoting fellowships in accordance with university authorities. None of these measures can be of any success if both funders and employers (in this case university administration) are not involved in a common negotiation.

Finally, in universities a large part of the research activity needs to be included under the general frame of the Masters and PhD programmes. These need to be designed in such a way as to lead to research, in particular PhD programmes. There will be no research-efficient faculty if it cannot relate the teaching activity in PhD seminars to research orientations. Moreover, the use of cooperative or shared doctoral programmes with foreign universities could be a lever for more research inside the university. France has designed “sandwich doctorates” with double acceptance of the diploma for the students and these have been received quite enthusiastically by both French universities and their partners. They do have the advantage of somehow promoting long-term relations between teams in both countries.

Research institutions need be sure of the ratio between researchers, research assistants, employees supporting research, PhD. candidates and post docs. What we found generally in the Arab world was a distortion between these different ratios.

A difficult issue relates to the evaluation systems and the way the academic institutions measure their own performance. We have noted that there is a low correlation of the research output –even when we restrict this to academic publications –with the number of academic/research personnel. There is very small elite of researchers who will publish a lot and a large number of persons who publish much less, figures show a large quantity of teaching personnel with less than one article per year. This might not necessarily be a default considering that the academic activity is not restricted to research. As we said before, even research has a multiplicity of forms. Somehow, the evaluation systems should not restrict to measuring papers in journals. This leads to a certain dis-embeddedness of science from society and even the market. AUB faculty for example, to take the results from a recent study, tend to produce more articles in journals internationally recognized but develop little science connected to society.

Patenting might not be the right tool to measure applied research (in fact it is not a good tool since it relates to commercial considerations as much as technical ones), but the fact is that there are too few patents. Here again the issue is not measuring patents but giving support to academics that have inventions that need to be patented. Patenting might be expensive, uneasy or not worth the risk as compared to other strategies (secrecy in relating to an actual enterprise, common business plans, exchange contract between the university and the company, creation of start-up..): but it should in any case be examined by a support and technology transfer unit. This unit needs a high degree of institutionalization.

Technology transfer units have bad reputation in most universities that have created one. The best example is Morocco, who has abandoned a large programme of support of these units in all its universities. They tended to be inefficient offices with little power and no capacity to undergo real negotiations with companies, patenting lawyers, and technical personnel. As various recent expert reports have shown in Morocco (under the auspices of the Ministry of Industry and the Ministry of education, Higher education and research), this situation is the product of the lack of institutionalization of these units and the lack of administrative support by the universities themselves. It appears that only one of these units have been able to evolve into a full-fledge entity that promotes local start-ups in the region of Settat and the support of "OCP Group", the national phosphate producing company and largest company of the country. Most university technology transfer units have disappeared or simply have never gone through the phase of declaration of creation. Khelfaoui (2000) did the same observation about Algeria. At the same time, Morocco is promoting with some initial success clusters in robotics, informatics, electronics that seem to be closely linked to universities but as totally independent administratively units.

Making innovation a clearly stated objective of public policy

Business incubators, technoparks and technopoles or industrial clusters in high-tech are not necessarily a panacea, or at least will probably be less of a solution than was initially thought of. But at the same time this is not to say that these efforts should be abandoned. On the contrary: these are usually initiatives that have a real meaning and, as far as they associate business practitioners, companies, and real markets, they should be promoted and supported. Technoparks and the like are also part of a regional economy, and they function not without developing strong links with actual economic and social entities that surround them; thus, they should be included into regional development considerations and economic programmes that support local businesses and not initiatives restricted to the academic dynamic.

It is often declared that the industry express little demand to the local university and research community, to technical centers locally based. This is only very partially true. All innovation surveys done so far show that there is innovation going on in degrees that are difficult to measure. Morocco and Tunisia did repeatedly innovation survey and it cannot be said that the industry does not need R&D or innovation. More than half the enterprises actually develop innovative projects but usually away from the university. This innovative activity of course depends upon the size and the sector of the companies. It should be noted that the national companies are more innovative than the branches of multinationals (even in sectors such as pharmaceuticals, chemistry, and electronics). Success stories of companies show that innovation is to be found in rather large "medium-sized" companies, around 300 employs, based on a long technical expertise that can be fed by continuous improvement in actual markets and interactions with clients and providers.

The same is true for universities. There is an 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 (a competitive advantage of the country), the cement industry and the agro-food. They have built very strong relations that are funding the research inside the lab as well as more contacts with industrialists. In Egypt, in the ICTs there has been a numerous group of companies that have developed their technological learning based on university expertise. Innovation surveys indicate that this effort can still be developed and it is not that the innovation is failing but rather that the support is more bluntly, not provided. Less that 10% of companies know the support schemes offered by the government in any of the countries where a similar survey has been done (Egypt, Morocco, Tunisia). It might be that they will develop in the future –as is hoped for example with the plan "Maroc Innovation" launched one year ago in Morocco.

The situation today is a sort of a paradox. On one hand, there is growth of innovation activities, in all kind of companies and even firms that were not interested in this activity some years before; on the other hand, innovation surveys indicate a low level of interest of the companies with public support to innovation. Companies in the surveys mention many reasons, but mainly two arise: bad knowledge of the support schemes, and little involvement in them, little previous experience. This low use of public support has no simple explanation, but it should be noted that a lot of companies do not even have knowledge of these schemes of support. One aspect is mentioned often: companies show a low level of confidence when the state is involved, and this confidence is part of the explanation that explains the success stories that we have portrayed in these pages above. A way to re-establish this confidence would be to channel the public support through market-based entities that is companies that act in the market and have a close working relation with the public entities that provide support. It should also be noted that if the State shows more support to labelling, legal framing and actual support to instruments that are unused in the promotion of enterprises, then companies will be more responding to the initiatives of the State. By and large, 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 the companies as well as some preference should be given to companies that wish to develop internally R&D activities.

Box 7. The network paradigm

Although different in the nature of the policy initiatives, Morocco and Tunisia show a common turn toward innovation in their S&T policies. Most of the 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. This is neither specific to the two countries or MENA. But […], MENA countries entered this innovation policy orientation rather later than other countries and have been focusing in some particular part without an overall national innovation strategy.

The first visible initiative in most cases was the promotion of technoparks. Tunisia was a forunner in the region with the El Ghazala technopole in Tunis, mainly oriented toward ITC. Morocco set-up its Technopark in Casablanca, Egypt its Smart Village close to Cairo and in Lebanon the University of Saint-Joseph created the Berytech. These are remarkable in their orientation toward new information technologies, focusing on rather small start-ups and are relating some training facility (university or engineering school) with enterprises. These technopoles or technoparks have been successful in housing many new small technology-oriented companies. Nonetheless, some assessments tend to doubt the efficiency of the linkage between universities and the universities or engineering schools and departments included in the technoparks (Mezouaghi, 2006).

Additionally, we can mention a series of frequently mentioned policies in the promotion of innovation policies 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 orientations. Suffice to mention that in the last five years, Tunisia and Morocco, as well as all 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 as such 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 possible 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 has certainly the advantage of flexible arrangements. It is also strongly inspired on innovation policy concepts developed in France and more generally in Europe. It has finally the additional characteristic of challenging the public research sector by asking it to establish linkages to the economy but without putting in danger the institutional and political position of academic institutions.

These policies aimed at promoting networks are too new to have received an impact evaluation. They merit our attention not only because they are new, but also because they are creating a whole set of new institutions and promote new players in the game. Basically what is at stakes is the creation of a whole set of new actors in between firms and public authorities.

More details: Arvanitis, R., M'henni, H. "Monitoring Research and Innovation Policies in the Mediterranean Region." *Science, Technology & Society*, 2010, 15 (2), p. 233-269.

Entrepreneurship is often said to be lacking and this is considered as explaining the low level of innovation. We believe this not to be the case in most Arab Eastern economies, but it isn't true either of economies that have a strong and centralized state like in Maghreb ; rather it appears that entrepreneurship is the most abundant resource. What seems to be more difficult is to secure regular market support and continuing expansion. The initial investment costs in R&D is probably less in "R" than "D" and the support schemes should provide for more than "one shot" support. Such an effort would need a more concerted action between the public entities involved in promoting economic activities. Single support schemes will always be short-term. Sustainable development of enterprises based upon innovation, R&D and technological development should be named as a special area of interest of the state.

Research systems: diversification

What kind of science systems is needed in the Arab world? The fact that research landscape in each Arab country is fragmented and in small scales, it is very debatable, as Mouton and Waast (2009) argued, whether one can talk of a science "system" in many of these countries, as they do not exhibit typical systemic characteristics. 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 the autonomy of the research.

Among the research units, there is a variety of research activities that can be developed. Up to a certain point, all countries experiment, as the research activity grows in number, a certain diversification. What can be found in a good research system is usually a wide range of specialists. In all areas, you would then find one –more rarely two– specialists. They usually feel quite alone and very among them would have the capacity to create a team dynamic that is sufficient to sustain a large team of specialists over time. Small research systems then have to confront this situation and it will be a difficult to force the creation of larger teams.

This issue is a complex one and to our knowledge there are many ways to deal with it. The institutional complexity of a research system is always a difficulty here. 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 calls back to the seventies, when national planning was *en vogue*. Moreover recent exercises in priority setting in Arab countries usually 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) that was built by CNRS 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 raise a catalogue not on the basis of declared priorities (whatever the forecasting exercise be used) but by combining these declared priorities with actors funding them. It is not our purpose here to show the detail of 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 the following one:

- Few strategic funding programmes with strong linkages with productive sector. The pursuit of some programmes, which imply the 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've already mentioned this aspect above. It suffice here to add that funding would then be given in priority when the alliances and collaborations are made. The areas for funding are nowadays well known: water, desertification, renewable sources of energy, agro-food and so on. The "Knowledge economy" areas could be among those programmes. The main evaluation criteria here would be relevance to local economy and intensiveness of linkages with 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 the economic interest is not the first objective, such as health for example. It is good to remind that in some countries, university incubators in areas that were not “strategic” have been commercially among the most fruitful sometime after. As the Lebanese CNRS states in its presentations, “if you consider health-related research as a cost, consider disease!”. What is needed is some support to these non-immediately profitable areas but where interaction with final users is paramount. Consider for example, the construction industry which has considerably developed its new building materials based upon intense exchanges between the companies that build, those producing the material and designers and architects. These areas related to users, real users, not users that are imagined by the promoters of the projects, could also be recollecting and using local knowledge, for example in agriculture, medicine, pharmaceutics, fisheries and the like. ‘Traditional knowledge’ is better introduced into research and new developments when it is linked to communities using this traditional knowledge. The main criteria here would be relevance to social needs and creation of strong teams.
- Areas of basic sciences. These are areas where collaboration with foreign colleagues will be sought after actively, where the objective is neither socio-economic, nor innovation driven. 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 [i] is right, the smaller the country the more beneficial this linking to foreign research. Doctoral students are a good investment if interesting employment schemes are devised for them after completion of their studies. But we should add to the “Wagner” proposal of a linking strategy, that this should be related to domains that are not necessarily those with a local productive base or practice base (such as hospital, or other economic activity). It also the “domains of the future” in the sense that local teams are incipient and there is not a strong interest. Excellence and novelty should be the main evaluation criteria.

All these types of funding need money that can be distributed along many different schemes: scholarships to students working into companies, funding of collaborative projects, direct subvention to research projects. Two aspects need to be reminded here from the experience of many countries:

Identify research. Research needs to be clearly identified and not only included into larger objectives like industrialization, promotion of food and health or other socio-economic objectives. Public budgets should clearly identify the research part. If not, sooner or later, a powerful alliance of misunderstanding and economic interest will always make it disappear in benefit of often “sexier” objectives.

Stabilize teams. Funding should go to teams, not individuals. Teams need time to be created. Very short term assignments in the form of research project can kill teams: the research teams 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 also have a stabilizing mechanism, a system that permits to maintain the quality of 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 in a 4 years period) here is maybe the best example since it generated a stable increase of research activities over a very short time in Tunisian universities.

Consolidating teams

In section above, we have insisted a lot on funding schemes. Before closing this chapter, we would also insist upon a possible suggestion for the "stabilizing" mechanism or the "unifying" mechanisms that we have been talking about. In effect, naming "clusters of activities" is not a sufficient manner to induce the creation of strong teams around specific objectives. One needs a mechanism that would permit to guarantee regular funding on the medium-term and not exclusively from outside sources. The Tunisian experience here could be examined more in detail. It needs to be driven by both universities and central state institutions, or at least recognized instances that can guarantee the validity of the "team projects".

Research in a social and economic environment that shows little interest for research is possible. The AUB in Lebanon is a good example of that: Lebanon has not had an environment very conductive to research. It has not had a 'hostile' environment either. But there was no real incentives for research and what the National Council for Scientific Research has done, historically, was rather to support already existing research areas more than promoting new ones. Usually, the original areas of research have been travelling to Lebanon through the Lebanese professors coming back from France or the USA and developing the research activities with their former European or American colleagues locally. International cooperation is thus the main tool of consolidating a competence: it does not permit to develop its own basis of research themes that are more relevant locally than they are for their foreign partners. Biomedical research at AUB grew in this manner and with its intersection with the medical practice offered by the hospital. Thus, professionalization of medicine entails conducting research. And this is not an 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, said he is 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 for Lebanon where medical diagnosis and lab research co-exist.

We can try to generalize these examples by saying that lack of professionalization in specific activities, are part of the riddle of research. The more professionals, the more research will be needed and called for. When professionals become more demanding, research can come in. This is how contacts have been built between companies and the universities in lost countries. But the contact does not happen only by funding.

A Brazilian sociologist, in the late seventies, when the research system in Brazil was beginning to grow, had gathered a series of interviews of researchers in many fields under the name of "Islands of competence" (Oliveira 1984). This is a most accurate wording for the situation in many Arab countries: a series of islands of competence, of niches of peculiar expertise have been built or are being built. These are relatively independent from each other even in similar domains. They will objectively seek the best expertise and will avoid local competition. They will also drive upon the national proudness as a way to secure funding. Local networking will be avoided. This situation has been the one experience by most Latin American countries in the eighties and nineties. New institutions were created that were geared to brokerage between productive entities and the universities. But these countries, as Tunisia did some ten years later, created "national systems of research" that were mainly promotion systems that were identifying and consolidating the research activity of individuals. These evaluation structures of research were funding an additional incentive for good publication patterns. Universities adopted similar schemes. Brazil, contrary to Mexico and Chile adopted incentive schemes that were collective rather than individual. It gives today Brazil a decisive advantage in research.

These evaluating/labelling schemes which take a series of forms have been strong instruments of promotion of research. They gave a decisive advantage to research for many reasons, among them because they permit to clearly identify a specific activity related to research. It also could permit to have better living conditions for researchers.

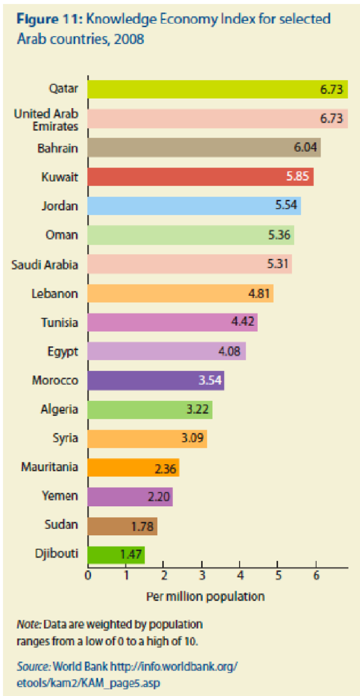
Interacting with others: international, regional and local networking

All the studies and interviews we had access to show that there are very few synergies between different scientific institutions in the level of the country or in a regional level: joint research projects among 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 the resources form Gulf countries would be useful in that effort. Many reasons make us doubt on this possibility, first of all 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 EU funding was coming in the form of project with competitive calls whereas most European countries were funding research by regular budgetary provisions to research institutions. The exception was the UK research councils that were funding a lot of their research through competitive calls. Nonetheless, the EU "framework funding" came handy and worked well, among other reasons because the EC research activities were parallel to the Construction of European institutions in other areas (economy, agricultural funding and so on). 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 to European partners. More than 400 million Euros have been distributed to projects involving Mediterranean partner countries; the partners Med countries in these projects received approximately 10% of this total funding.

The idea that inter-regional cooperation will be promoted by Gulf, Turkish or Iranian funding is somehow utopia. Bilateral programmes might be more efficient for this, and we should remember that European countries have not abandoned their bilateral funding of research and higher education in the neighbouring regions. France, Italy, Spain, Germany and to a lesser extent the UK have been active in funding research through bilateral programmes in the Middle-East region or the Maghreb. The good idea to use the full capacity of the region by using the Gulf funding, or any other source, does not make sense if it not accompanied by a policy with stated objectives. Inter-Arab cooperation is thus quite low; nonetheless, more funding is available and we believe that only time will tell us if the increasing money from institutions such as the funding provided by Qatar foundation will fill the gap. It should probably forget entirely about the once stated objective of national 'self-reliance', at national level or –even more a utopia—at Arab regional level. Rather, we believe that the driving force will not be funding per se but professionalization of the funding mechanisms. The areas of medical research funded by Qatar foundation have been appreciated by the teams because of the seriousness and professionalism of the evaluation and funding mechanism. Funding research is a profession, and there is a clear need for transparency and professional rules in using the money given through competitive funds. It is also clear that no research will ever

Figure 22. Knowledge economy in the Arab World



Source: UNESCO, 2010:269.

grow satisfactorily if the internal mechanisms for spending external funds are not modified in most research institutions. Today, it is less money that lacks than management capacity to spend the money. It would be our recommendation to promote systems of management of research and innovation, and make it a topic of high priority for training in the near future.

A closely related issue is the fact that networking as the project of funded projects is very efficient. Again the experience of the EU 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 tend always to expand in order to interest larger networks. The professional networking is thus particularly efficient and grounded on the actual practice of research. There is no reason why this kind of networking wouldn't work in specific professional areas. Of course, again this seems possible only at the level of disciplines or specific subjects.

This kind of linking strategy would make sense if it permits relatively strong research teams to participate. Participation to international collaborative networks without the parallel consolidation strategy would be like entering a river; it will end dissolving in the sea. Strong poles of the network, that permit to gather many researchers working in one topic would be able to profit from the flow of resources that are such networks. Networks are not a sufficient strategy, since they need to be complemented by the consolidation of teams that we have been talking above.

Having said that we need always to have state as one component of the "network" model II produce knowledge because either centralized model (Tunisia and Jordan) or the major striving force of competing war machine of the historically missionary universities.[32] The World Bank has a quite clear view of what it calls the Knowledge economy. It has designed a Knowledge Economy Index (KEI) which has a rather clear view of the future (liberalization motto: more S&T, more innovation, more entrepreneurship, more privatization, more flexible markets, and less control, less state), (see FIGURE 22– note how this model has ranked Arab countries in such a way, making Qatar and the UAE the champion of knowledge economy) We advocate for a more diversified model to take into account the different types of sciences, as well as the different roles of the state according to the issues addressed.

Making research a political topic

During the Arab Summit of March 2010, the Heads of State adopted a resolution mandating the General Secretariat of the League of Arab States to develop an S&T strategy for the entire Arab region, in co-ordination with specialized Arab and international bodies. This strategy is due to be submitted to the upcoming Arab summit in 2011 for adoption. It is expected to

[32] These universities do not really fulfil a uniquely religious missionary mission. Samir Khalaf (2012) called them "ungodly missionaries".

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.

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 envisage both national and pan-Arab initiatives in about 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 lie in identifying some of the national challenges that Arab countries face. It will be to make research a topic in itself in the political discourse. Political support for research and innovation (or "science and technology" as it is usually termed) at the highest level is required, coupled with affirmative government action, an upgrade of existing STI infrastructure and an increase in GERD

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

Refereed Academic journals

The Arab world needs more journals to publish scientific results. The objective should be to create a dynamic of exchange between members of the scientific community locally and to mobilize allies from peers, the public and decision makers. It should be noted that the main dynamic behind the publication of journals is the existence of a lively scientific community. Large publishing companies (Elsevier, 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 World could profit from this tendency; it should also encourage publishing in Arabic when –and only when this condition is given—there is a group of scientists that is demanding it. The main difficulty here is that academic institutions for reasons that are purely institutional 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 that might make sense; it is 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 that want to defend the journal feel such a 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 dissemination tools for scientific and technological activities. Citizens shouldn't be kept in the ignorance of what happens in their own countries in the laboratories, schools and universities.

Diaspora options

As we saw in the section about the brain drain and brain gain, there are many lesson learnt from the two experiences that the Palestinians have in the last 15 years, namely TOKTEN program and PALESTA Network. We think it is extremely important that UNDP or any international organizations foster the temporary stay of scientific expatriates in their country of origin. All countries in the Arab world need the equivalent of PALESTA. This network costs little money but can harness development in the Arab World.

Better living conditions

Scientists and engineers would probably accept comparatively lower salaries from their colleagues in the USA or Europe if they have better conditions in the academic institutions in their own country.

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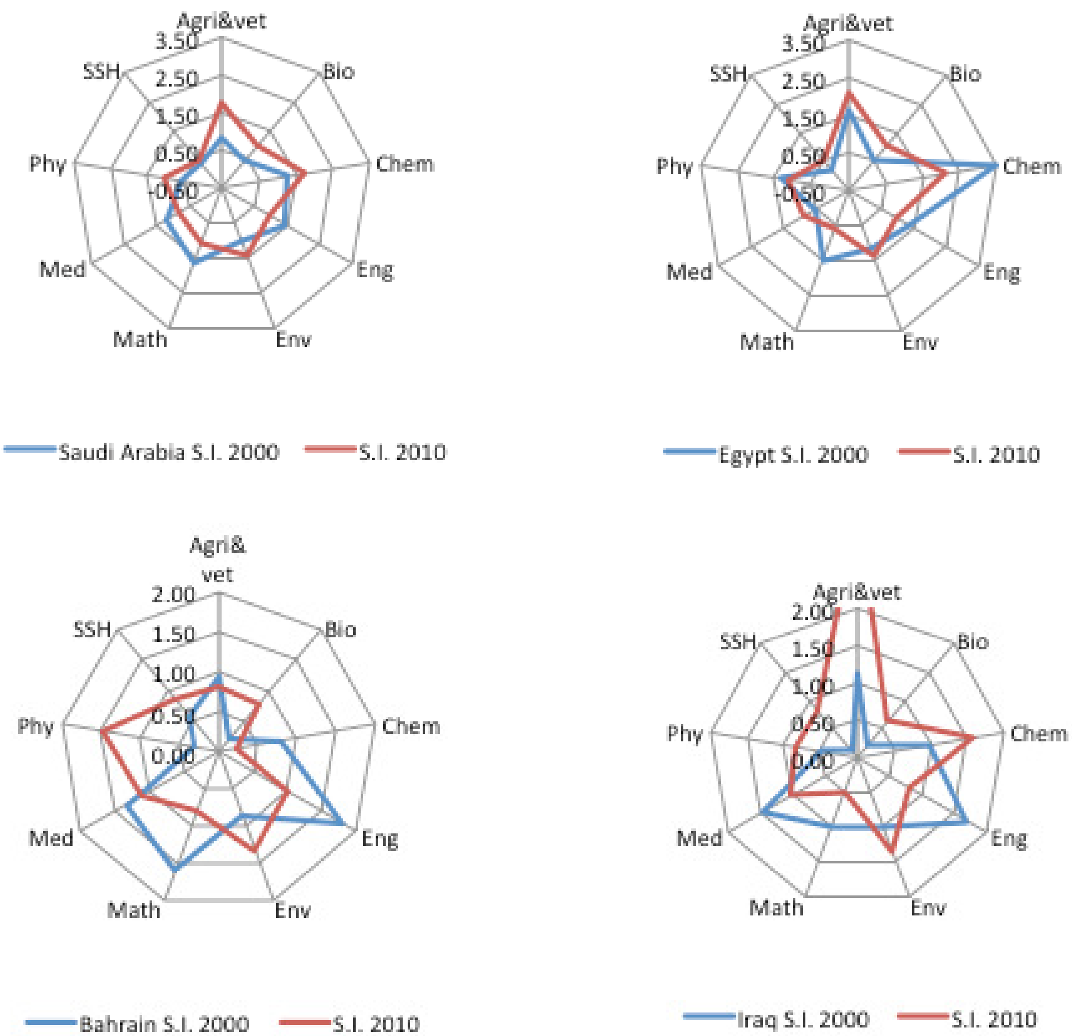
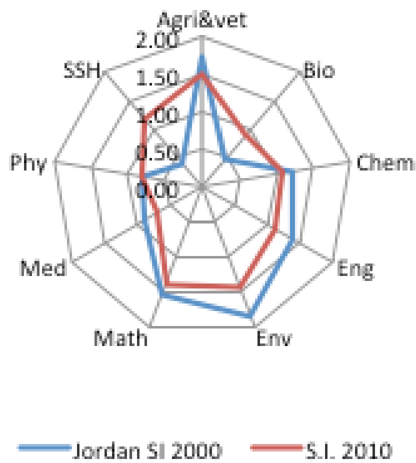
إضافات- المجلة العربية لعلم الاجتماع. العدد 10.

ANNEX 1: BIBLIOMETRIC INDICATORS ESCWA 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. Other indicators (such a as co-authorship

Figure 23: Specialization Index in Arab Countries (2000-2010)

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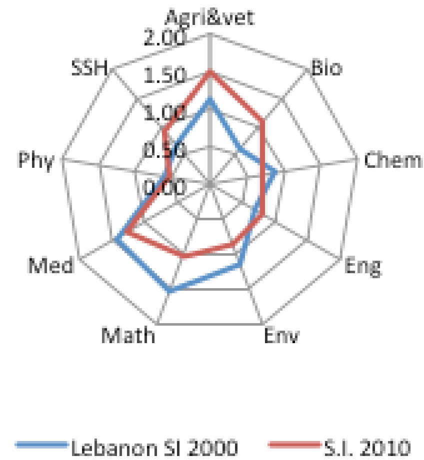
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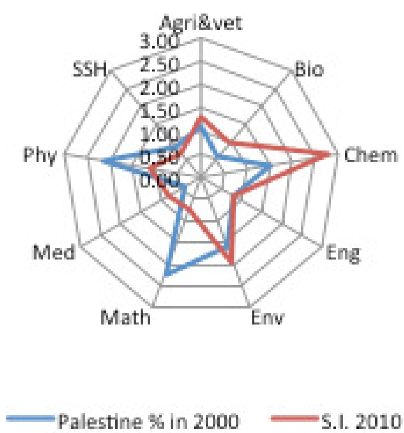
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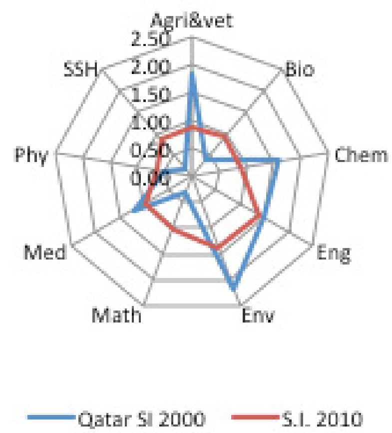
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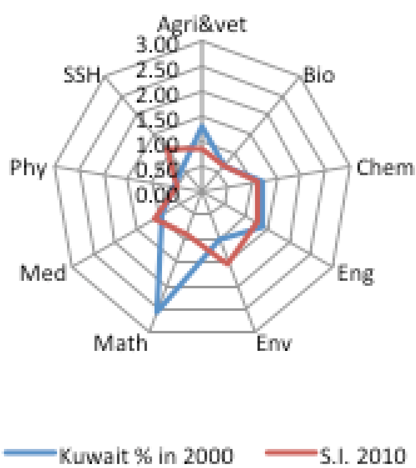
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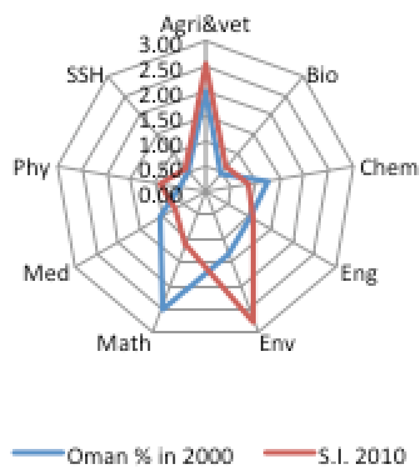
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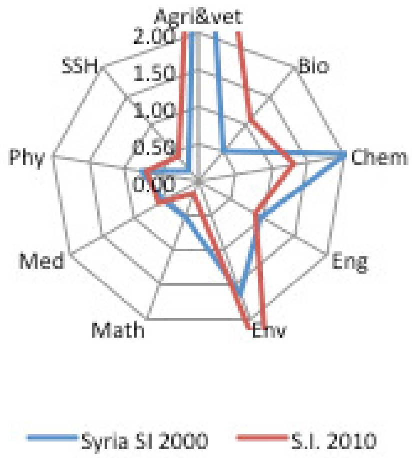
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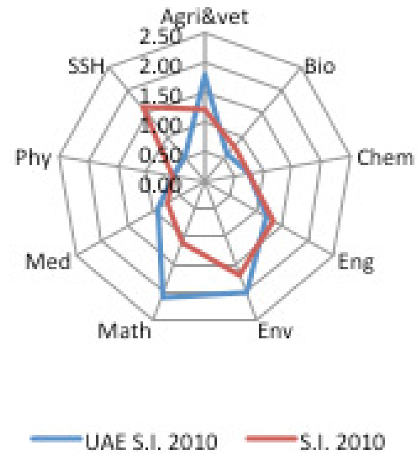
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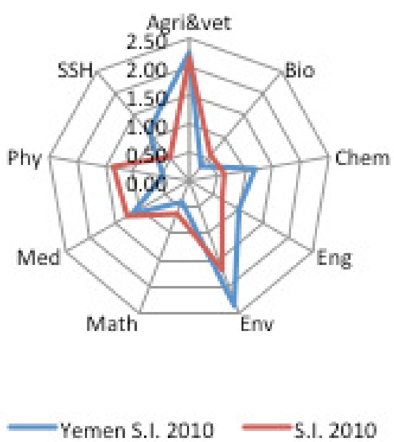
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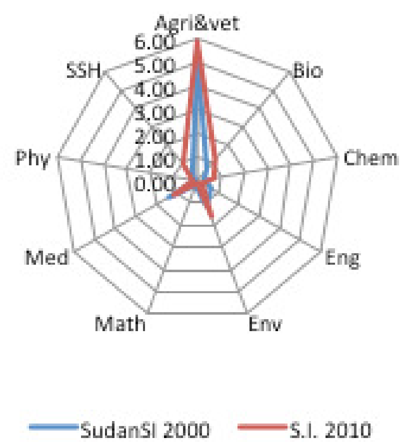
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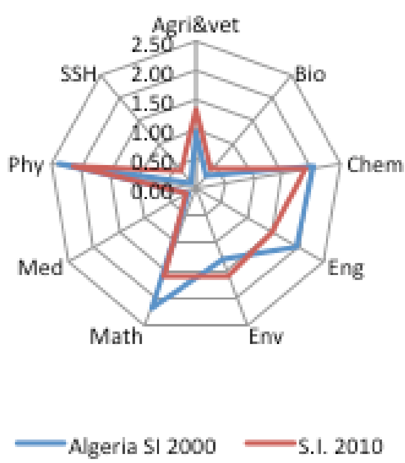
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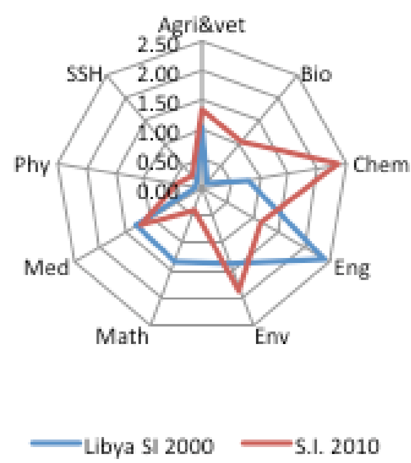
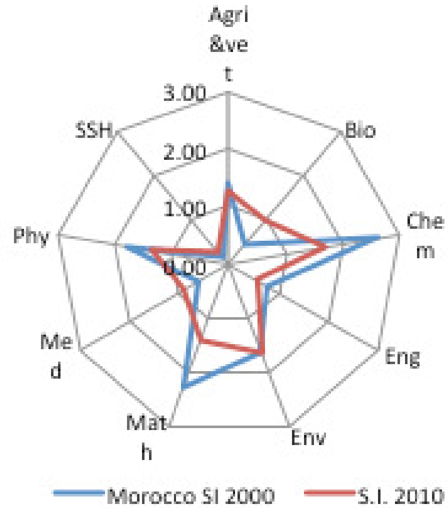
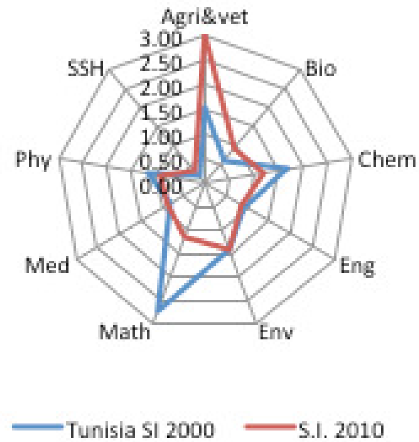
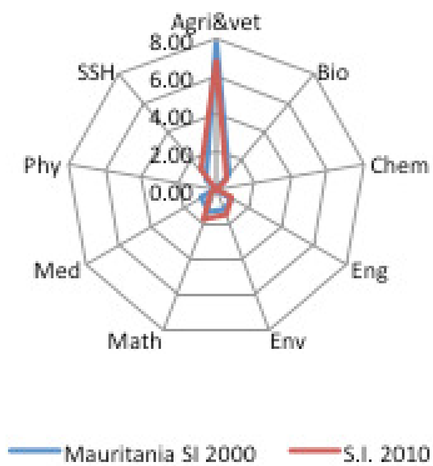
Chem
Eng
Env
Math
Med
Phy
SSH
2.50
2.00
1.50
1.00
0.50
0.00
Algeria SI 2000
S.I. 2010


Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
2.50
2.00
1.50
1.00
0.50
0.00
Libya SI 2000
S.I. 2010



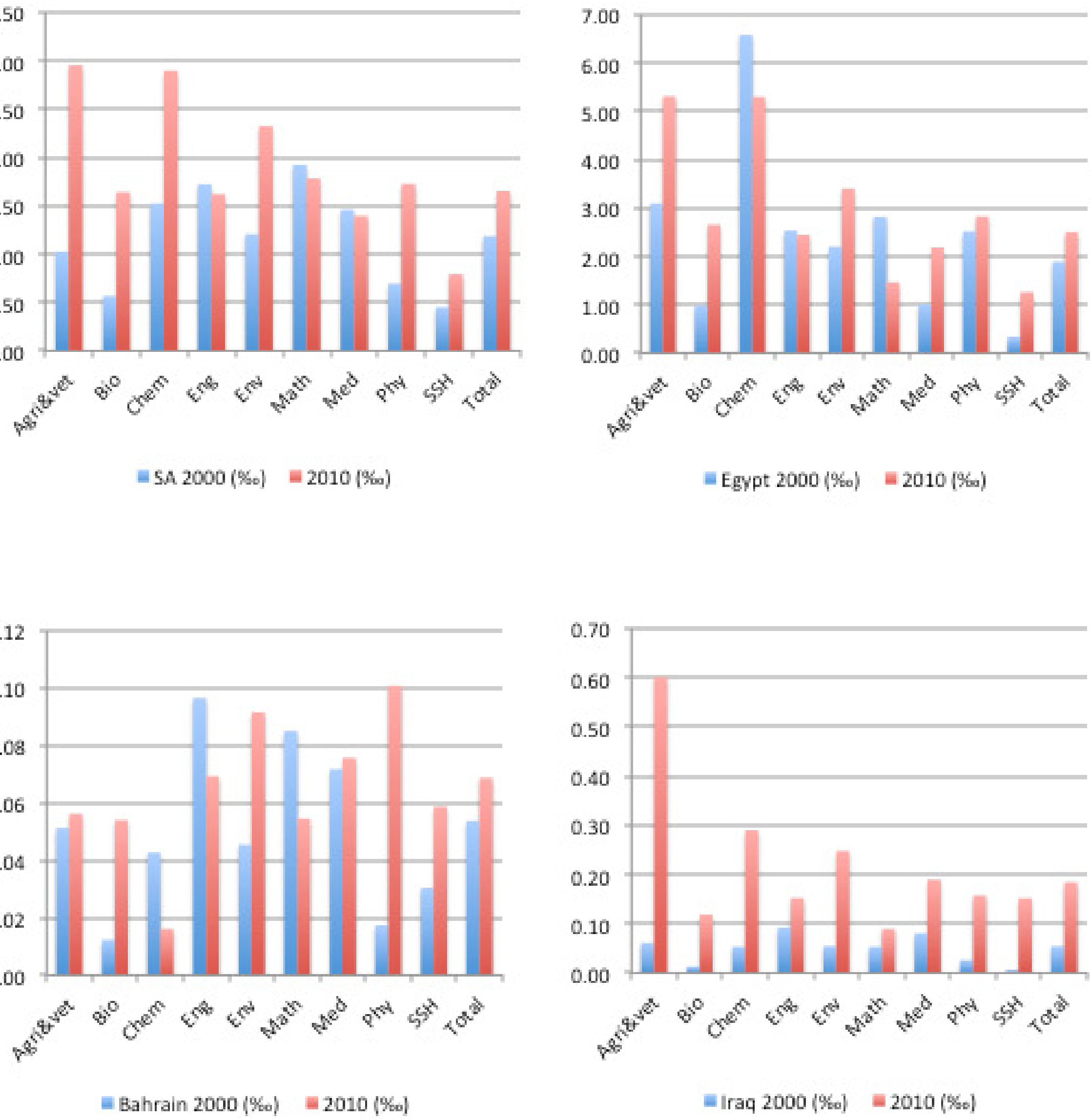


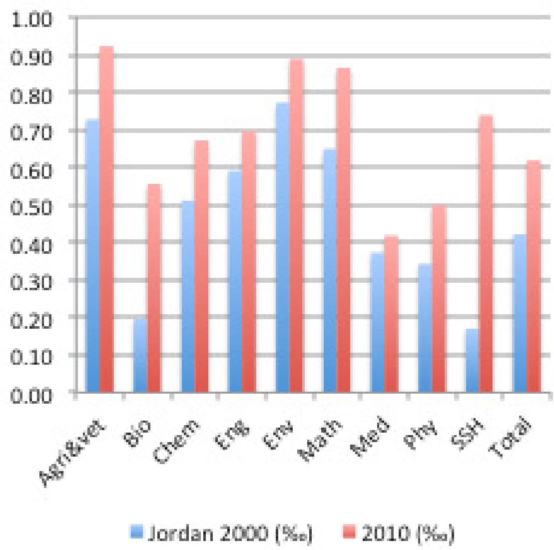


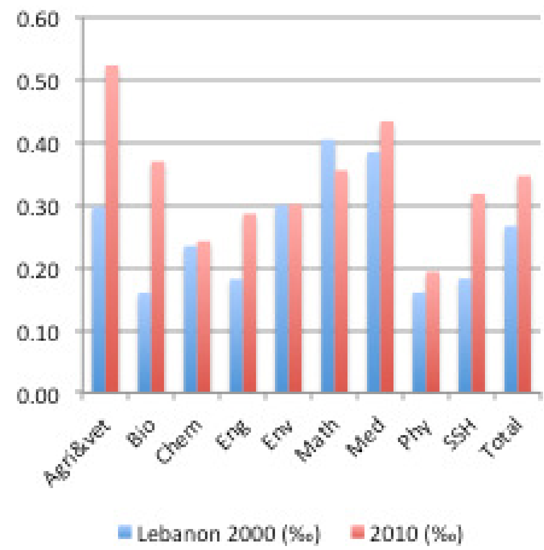
Note: Specialization index=1 when activity in the domain is similar as the country's activity in the world production; above 1 there is a specialization in the specific domain; below 1 there is less specialization

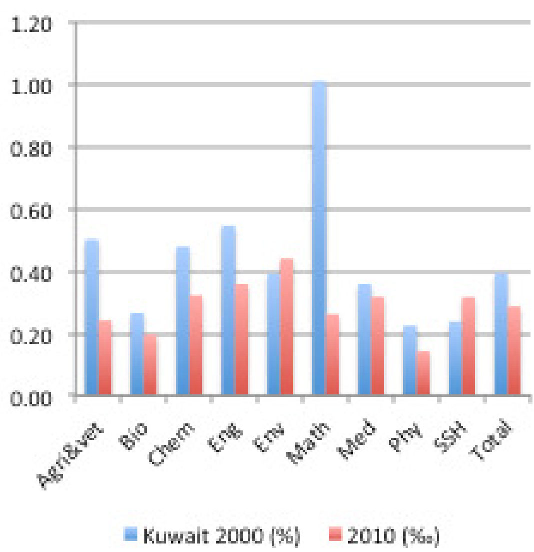
Source: own elaboration, Scopus data delivered by http://www.scimagojr.com/

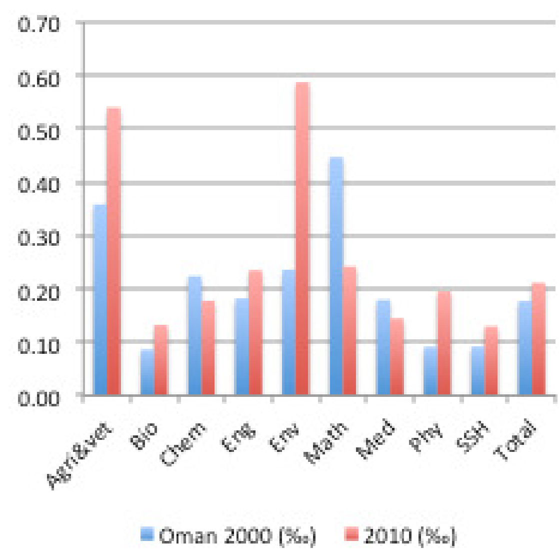
Figure 24: World shares in each scientific domain (% from the total publication) in Arab Countries (2000-2010)

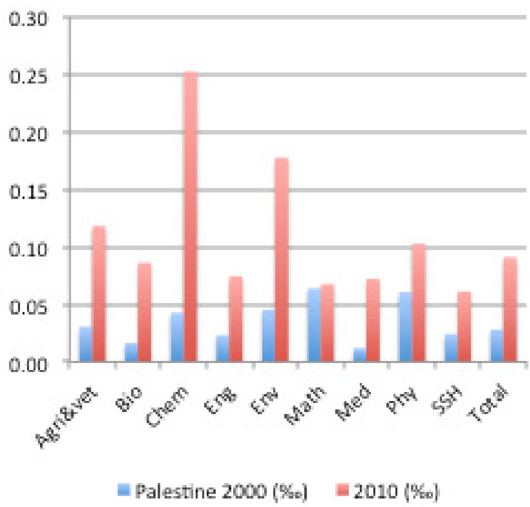


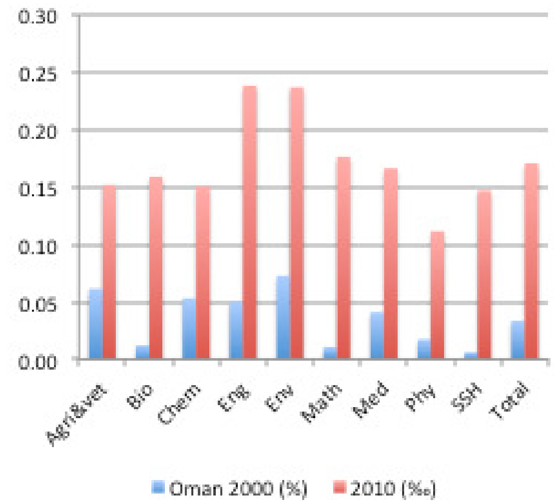

1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Jordan 2000 (‰)
2010 (‰)

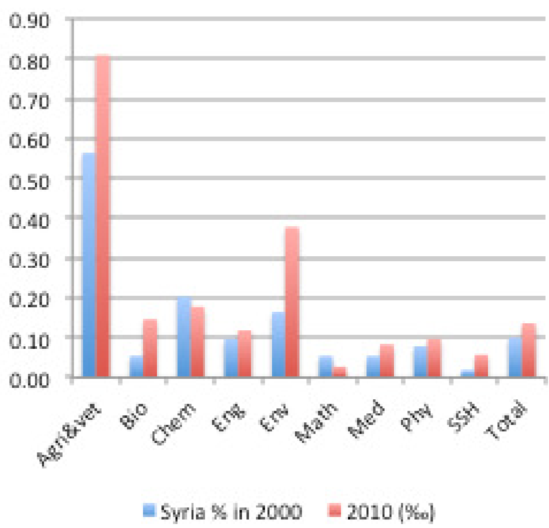

0.60
0.50
0.40
0.30
0.20
0.10
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Lebanon 2000 (‰)
2010 (‰)

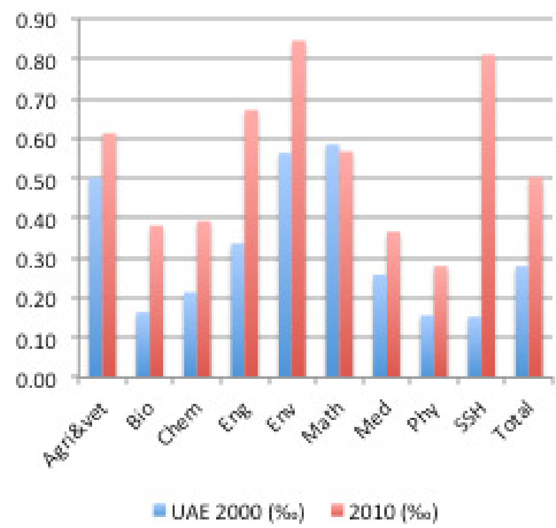

1.20
1.00
0.80
0.60
0.40
0.20
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Kuwait 2000 (%)
2010 (‰)

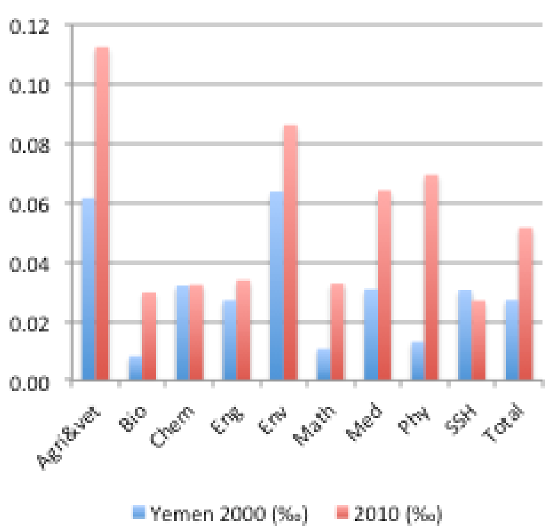

0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Oman 2000 (‰)
2010 (‰)

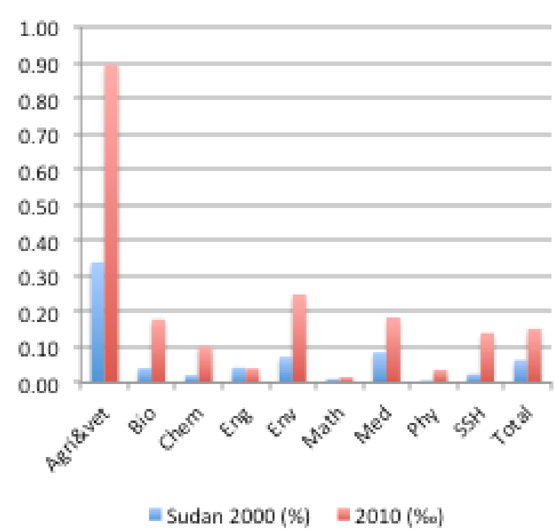

0.30
0.25
0.20
0.15
0.10
0.05
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Palestine 2000 (‰)
2010 (‰)

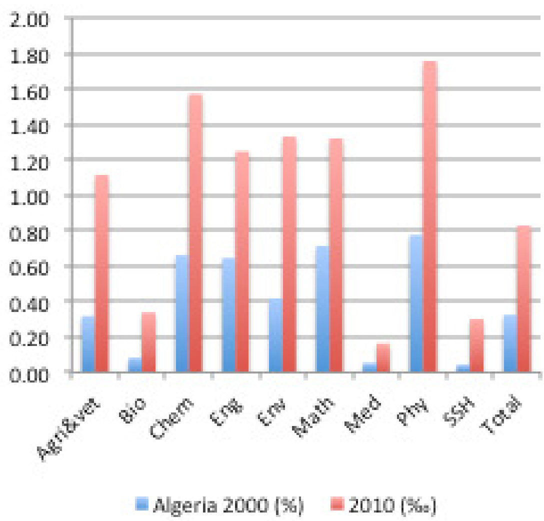

0.30
0.25
0.20
0.15
0.10
0.05
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Oman 2000 (%)
2010 (‰)

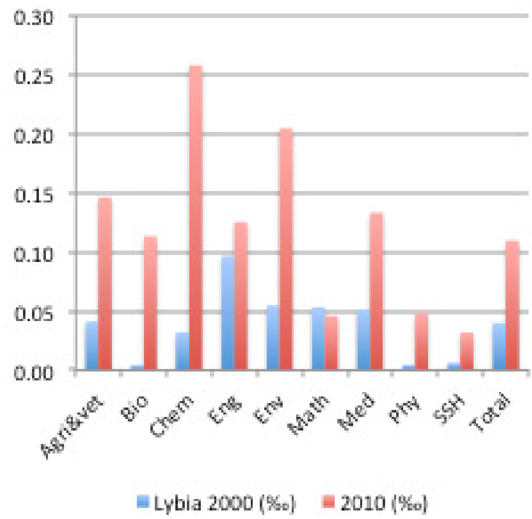

0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Syria % in 2000
2010 (‰)

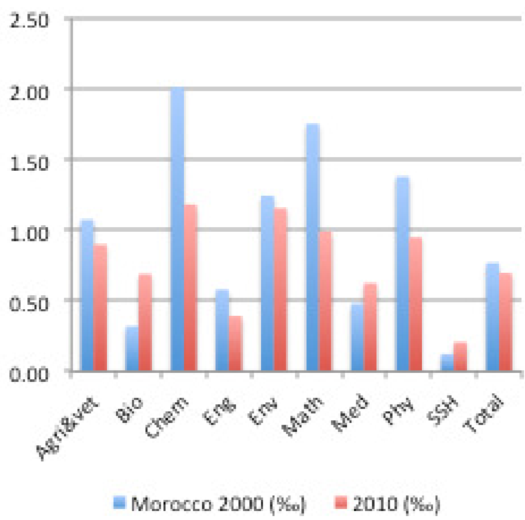

0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
UAE 2000 (‰)
2010 (‰)

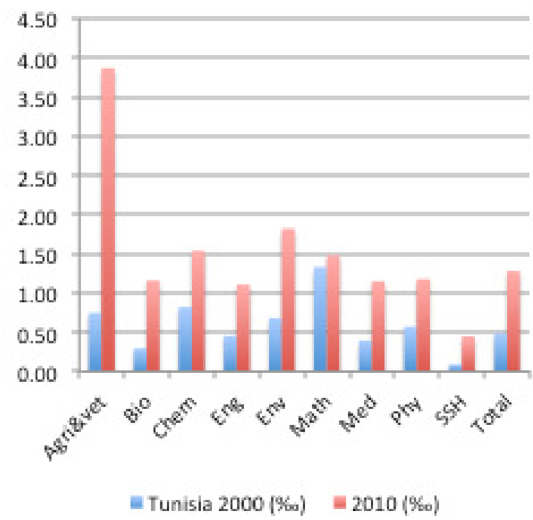

0.12
0.10
0.08
0.06
0.04
0.02
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Yemen 2000 (‰)
2010 (‰)

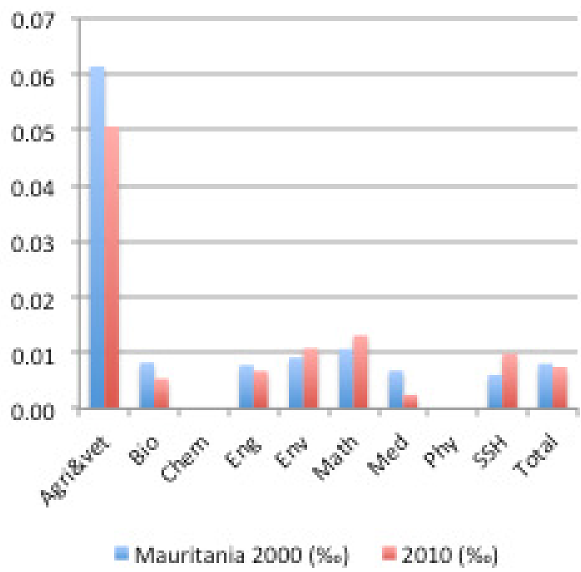

1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Sudan 2000 (%)
2010 (‰)


2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Algeria 2000 (%)
2010 (‰)


0.30
0.25
0.20
0.15
0.10
0.05
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Lybia 2000 (‰)
2010 (‰)

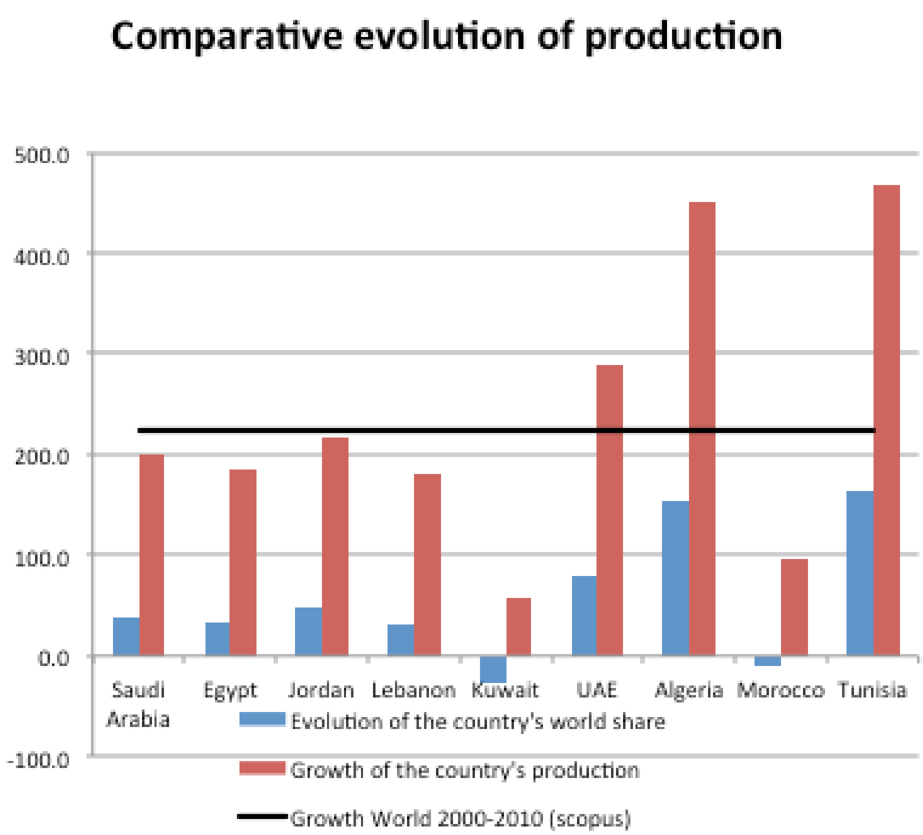

2.50
2.00
1.50
1.00
0.50
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Morocco 2000 (‰)
2010 (‰)


4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Agri&vet
Bio
Chem
Eng
Env
Math
Med
Phy
SSH
Total
Tunisia 2000 (‰)
2010 (‰)



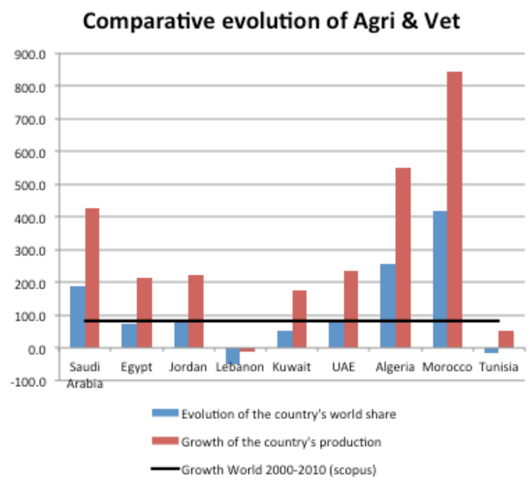
Source: own elaboration, Scopus data delivered by http://www.scimagojr.com/

Figure 25: 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 26: Comparative evolution in Agricultural sciences, Veterinary and Biological Sciences



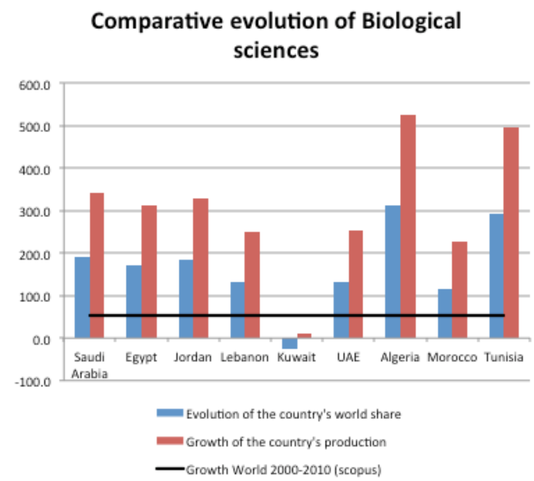
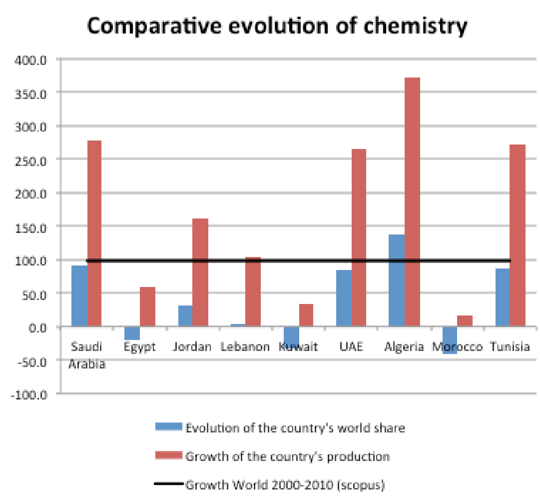


Figure 27: Comparative evolution in Chemistry and Engineering



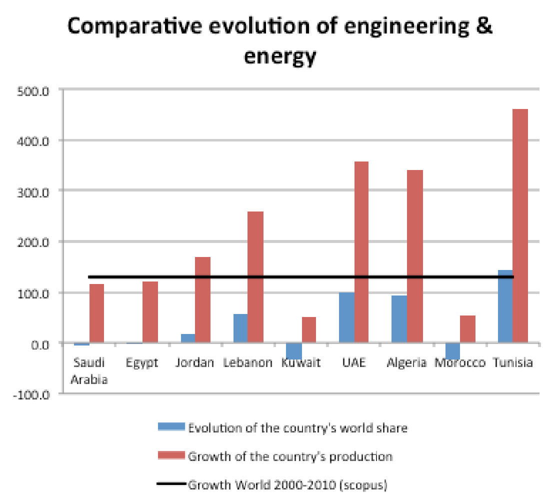
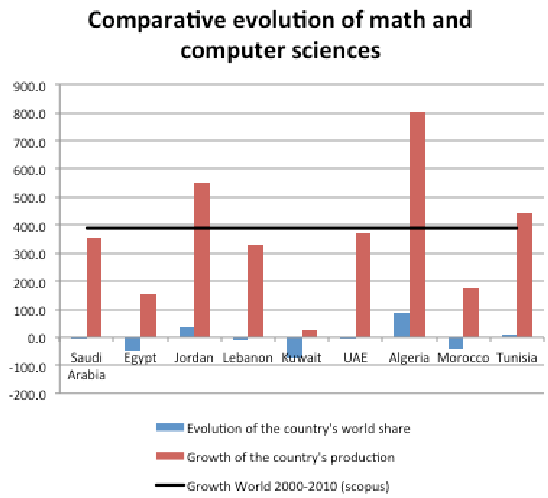


Figure 28: Comparative evolution in Mathematics, computer sciences, and Medical sciences



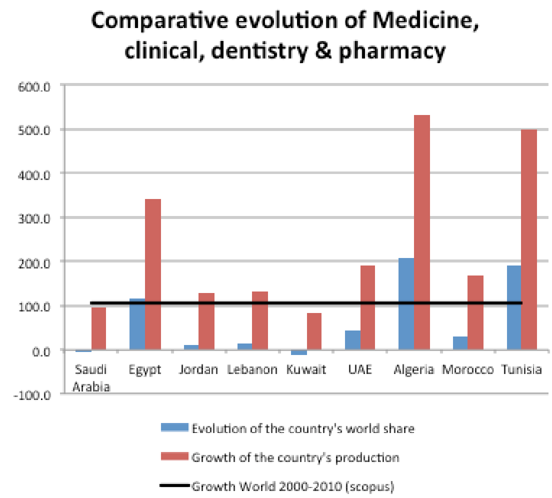
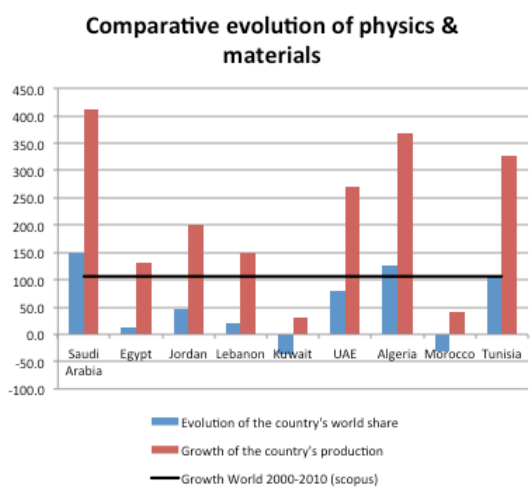


Figure 29: Comparative evolution in Physics and Social Sciences and Humanities



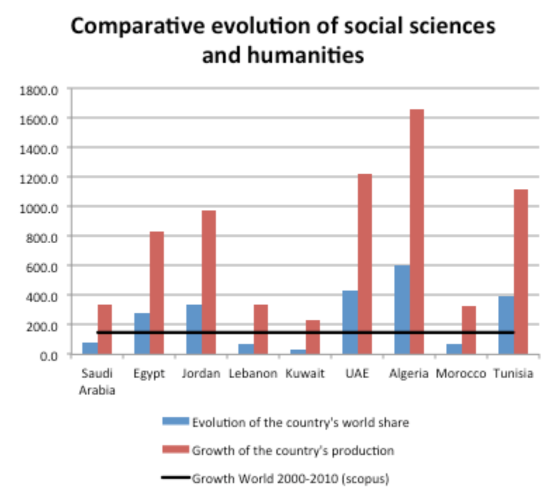


Figure 30: Comparative evolution in Environmental sciences

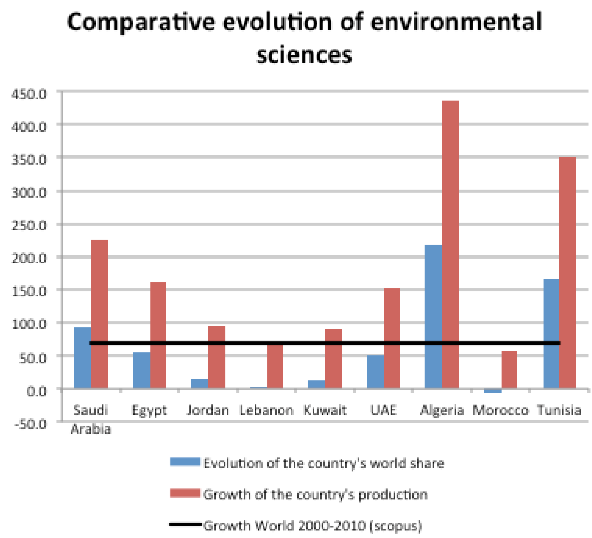
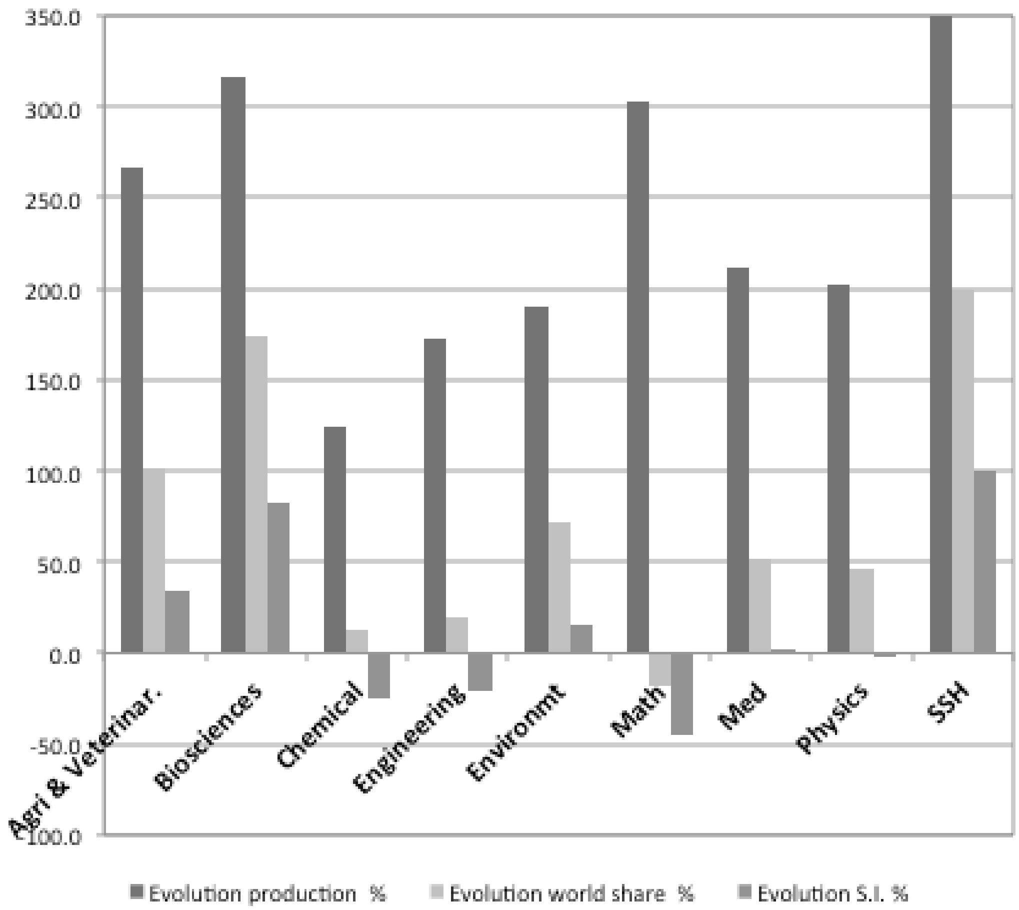


Figure 31: Comparative evolution of main indicators per discipline



Note: Scopus database as a whole has variations. The specialization indicators follow partly these variations. 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 32: Total production and international co-authorship