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Introduction

> Science is a sort of metaphor for politics, because its ostensible rationality covers up any messy conflicting interests and is also the purest expression of development and modernization.
>
> (Siino 2004: 73)

In June 2014, our university department organized a tribute to Samir Khalaf, who is a professor of sociology at the American University of Beirut (AUB). When we sent this invitation to our mailing list, we received seven phone calls and emails asking us when Samir passed away, and four other emails asking when he retired. This anecdote alludes to the lack of tradition in the Arab world of giving a tribute to someone who is still alive or still has a professional life. It indicates the absence of a "scientific community" in Lebanon that acknowledges the contribution of its members. Of course, traditions are the result of an active re-enactment of our history. Scientific, academic and disciplinary communities are fond of these small rituals that revive the intellectual standing of its members and permit us to gauge our own position as a group within the "community." What is at stake, in any of these informal evaluations, is where we stand, and at the same time to which group we belong. Institutions make some of these boundaries,[1] and an important motive for our book has been to understand the institutionalization process that has taken place in the Arab world, and particularly in Lebanon. We will ask ourselves why it was so late, why the scientists waited so long to create an active scientific community.

In March 2014, the Lebanese Association for the Advancement of Science held its twentieth annual conference. It was an opportunity to present more than 400 posters and presentations in the natural and exact sciences. For a small community, in a small country, these numbers are relatively high; it is not so much a question of the mere size of the scientific community, but rather a question of proportion. The researchers are there, but is there a community? "In this country, you can find a specialist in any specialty, but you will never find two persons in the same domain" was the witty remark of a research director who we interviewed last year. Maybe it appears to be an exaggeration, but certainly it reflects a widely felt reality. This lack of "community" appears so strange in a country where the notion of community is so present, referring to the religious and social "communities" that are recognized in the political life of the country. And maybe a part of the answer lies, precisely, in the division of the country into its many competing fragments. The particular context of Lebanon is a nuance of a phenomenon evident throughout the Arab world.

The first issue we would like to tackle in this book are the reasons the scientific community is so little recognized in Arab countries, despite them being rich with universities and hospitals, and having some level of scientific production. On some level, we question whether the problem stems from institutions or whether it is a result of political matters, in which Arab countries are comparatively less active than other regions, like Latin America. Is it possible that the problem is grounded in deeper social and political problems that influence the production of scientific knowledge?

1 Identifying the local engines of globalization in research

We were not initially guided by this questioning about the scientific community. Rather, we arrived at this issue, and as we will see it will relate to one of our main conclusions. As we know, since the seminal book of Roland Waast and his colleagues (Gaillard *et al.* 1997a: 12), scientific communities were born in the age of *national science*, after colonial rule withdrew:

> For almost three decades or so after the War, national mode of scientific development promoted the strategies of import-substitution and self-reliance in the overall economic policies, also governed the organization of science and the goal orientations of scientific communities.

But this new era of "national science" has been short-lived: we can date this period from the independence or liberation wars, when the nation states were set-up against colonial rule, until the 1980s, when globalization became the new name of the game.

At that time, until approximately the 1980s, research was essentially equated to science. Nation states were creating new institutions, among them universities and public research centers. The debates on development always mentioned economic growth, and science was just a background activity useful for technological development. All that counted was technology and, for those who recognize the unequal exchanges between developing and rich countries, technological transfers. The endless debates on technological development translated the frustration of those newcomer countries that lacked access to up-to-date technology. This debate, as Ruffier (1991) claimed, was terminated when it was found out, in the process, that technology cannot be bought: it has to be developed, it has to be incorporated locally and mastered in-house, it has to rely on previous knowledge, it has, also, to rely on research. Technological developments do not depend on research exclusively; they relate to the technological experiences of companies, among which R&D and public research are, indeed, vital inputs.

Since the 1980s, a second fundamental change has taken place: globalization has profoundly affected research. Research is no more an exclusively national endeavor. The divided world in the aftermath of World War II gave rise to a hierarchical world where centers and peripheries are more widely distributed. Scientific collaborations are all about how to link this “national” science (that is, the local scientific community) with the available international competencies, as we will see later.

As a result of this globalization process, science has grown very rapidly. Estimates[2] of the world expenses in R&D show a figure around €1,113 billion, which represents 2.15 percent of estimated world GDP; this figure has grown 77 percent in seven years, from a low of €640 billion in 2000 to today’s €1.2 trillion. Over the same period, world GDP grew at a slightly slower pace (72 percent in seven years).

Not only has the scale of science changed in large proportions; its geographic distribution has also changed. The world production, in terms of publications (excluding social and human sciences) is no longer entirely bound to North America and Europe. The geographical distribution is as follows: 38.6 percent of publications come from Europe, followed by North America (28.4 percent) and Asia (24.3 percent). China represents around 11 percent of the world share of publications. New players in world scientific production have appeared since the early years of our new era: China, India, Brazil, Turkey, South Africa. The club of countries that give priority to research has grown, and now includes countries such as Mexico, Thailand and Chile, for instance. Later, we will examine in more depth these important, yet limited, changes.

This increase in the size of science also reflects a larger scope of activity and a stronger interest in the results of research. This was the impetus for the increasing importance of PhD programs created in every country and, as a result, flows of students worldwide have soared. The information and telecommunication technologies created a global information infrastructure, which has triggered further collaborative activities within research networks and for users of scientific knowledge.

The governance and predominance of science in political debates (think of climate change, genetically modified organisms [GMOs], international property rights, negotiations on drugs, biodiversity and the like) has changed. Scientific questions have become global. Scientists of the natural and social realms have become accustomed to thinking about issues at the global level. Of the two scientific fields, this phenomenon possibly occurs more with natural scientists. Objects are global; communities of specialists are global; training specialists has become a question of feeding an international distribution of competences, making every new PhD candidate a future emigrant. Caroline Wagner (2008), among many other authors, has quite brightly defended the idea that international scientific networks are essentially made of individuals who seek collaboration with peers having mutual interests and complementary skills around the world. In this globalized world, international collaboration functions as a global self-organizing system through collective action at the level of researchers themselves (Leydesdorff and Wagner 2008).

According to this view, in this global era, the individual researcher becomes the hero of international collaborations, by taking decisions where individual interests are the main driver; the basis of this explanation is the idea that the individual recognizes potentially interesting collaborators and is able to evaluate and seize the expected outcomes of the planned collaborations. Leaving aside many flaws[3] in the argument, we believe this view of a sort of gigantic, worldwide network of scientists, in which competences and resources circulate easily, does not correspond to reality. Individual scientists, even the best among the best, need to be able to objectively "choose" their collaborations, a judgment that relates to her/his insertion in their local environment, institutionally, politically and economically. The existence of a local scientific community as well as the institutionalization of scientific activity plays a very important role here. It is through the participation in local training and scientific teams that the young, individual scientist can become increasingly involved in international collaborations and, consequently, be involved in the global scene. This is because, locally, policy instruments have been used to consolidate research activities, doctoral programs and research units, making research a recognized item in policy, budgets and organizations. Personal decisions are important, but choices are also influenced by other factors that go far beyond what we are usually ready to accept when assuming that research (and international scientific collaboration) is beneficial.

We will insist on this aspect, since international collaboration will be an important part of our book. However, for clarity, we want to follow this simple idea that globalization is also a matter of locating the actual places where globalization is based (Sassen 2007). The particular networking that scientists produce through their movements (for training and research), their travels in order to participate in international conferences and meetings, the broad and pervasive movements by the scientific diasporas in foreign countries to study and occupy post-doc positions or work abroad in order to acquire a specialty that will permit a better return home – all these more or less permanent migrations – are in fact dependent upon some local engines of globalization.

Two processes apparently build these engines of globalizations. First, there is an institutionalization process (Vessuri 1994) in which "capacity building" is the first step toward creating research institutions. In most countries where research was not a sizable activity, through a period that can be named "national science," scientific research has been closely linked to universities, instead of national public research organizations. The creation of these particular social institutions goes well beyond the objectives of this book. Nonetheless, the establishment and consolidation of research activities inside the universities has become a crucial aspect of the institutionalization process. The evolution of research, the acceptance of science as a legitimate source of knowledge, is not a mere question of "development": it is a question of political willingness and of its embodiment inside the national institutions. We would like to trigger a discussion, in the Arab world, on these aspects inside the universities, inside the local scientific communities.

The second process at work is the building of the scientific community – we could add the "national" scientific community – and this process, as explained above, is dependent on the historical momentum, and the resources available based on whether the political system is willing to pay for research. In the case of Lebanon, the apparent lack of a scientific community is also a reflection that is valid for a large majority of countries in the Arab world. As proof, very few, if any, Arab scientists are involved in any of the international scientific debates we have been discussing in these pages.

Since the 1990s, policies have moved away from the import-substitution model to the neoliberal dogma (the "Washington Consensus" and "post-Washington Consensus") that oblige us to think about socio-economic issues only as market issues. The institutionalization process that was slowly taking place was shattered by the lack of resources of public institutions, which directly impacted universities and public research organizations. Thus, science policies also changed.

All these processes (institutionalization, community building and internationalization) were driven by certain ways of understanding the economy and its relation to knowledge. Since the end of the 1990s, the emerging *knowledge economy* became the concept of the day. At the start of the new century, the world appeared increasingly multipolar, with "knowledge" playing many different vital roles. The (once known as) developing countries seemed to have disappeared from the radar within the new knowledge economy. A new concept was needed for what Alice Amsden rightfully called "the Rest," in contrast to "the West" (Amsden 2001). If "developing" is no longer the right word for these economies, what should it be? Have the modes of producing, using and diffusing knowledge changed so much that development itself became an obsolete concept? Are we all living in a "flat world" (Friedman 2005) without borders, where power structures have disappeared? Whether one views globalization as beneficial or harmful, there is a tightly interconnected economic structure with science and technology, as stressed by the Arab Knowledge Report (Al Maktoum Foundation and UNDP 2009).

Multipolarity, indeed, does not indicate the disappearance of hegemony; on the contrary, it is a clear indication that several large centers of research and innovation will exercise hegemony over the field, in a far more aggressive competition than had existed in the divided world of centers and peripheries. If we look at the geographical distribution of the number of articles over time (1978 to 2008), the distribution has not changed for most countries, although absolute numbers have grown immensely. China, Brazil, South Korea and Taiwan are still exceptions (see Figures 2.7–2.10). The next to come seem to be South Africa, Turkey, Thailand, Malaysia, Chile, Argentina, etc. It is not so much a question of more numbers of publications, but rather a changing position that these countries are acquiring. Losego and Arvanitis (2008) have proposed to call the countries that belong neither to the old center nor the new emerging economies as "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 countries do not have financial instruments capable of influencing the broader goals of knowledge production, unlike the United States, the European Union and a small number of Asian countries. The research "agenda," as it is usually named, is still set by research groups that belong to a very few large countries, mostly those belonging to the OECD. Knowledge and research seems even more unequally distributed than commercial goods and economic wealth, and strangely enough seems to be very much tied to locational advantages, rather static over time, situated geographically and linked to age-old institutions. This translates into the fact that research policies have been stressing the importance of the public sector, of strong locational advantages – which means rooting the research activities in a specific country because of some advantage you can only find in that specific space. This determination of the research agenda by some very specific places, in some very precise institutions and by some very particular research groups is confirmed by the fact that contrary to our usual thinking (reinforced by the triumphal statements one finds in newspapers), emerging countries have still not been very much able to modify the main flows of investments in R&D (Larédo 2003). Even if growth of scientific production in intermediate urban localities can be observed, rather than a concentration in very large cities (Grossetti *et al.* 2013), the main places of production of scientific research have not changed a lot since the end of World War II. Numerous literature have been written to show the changing ranking of countries and the contribution of research to their wealth. Most, invariably, end up at more or less the same ranking, an issue we will tackle in Chapter 1. This issue of the position of a country within the world circulation of knowledge is probably different for innovation, as opposed to research, since not all innovation is research-based, and since innovation can be more multifaceted than research. Nonetheless, non-hegemonic countries have usually adopted an incremental development model, based on strategies of technological catching up. The experience of the Asian Tigers is precisely one of catching up, learning and adopting technologies, until they become key tools of economic development.

In brief, we need to examine the local roots of globalization, or rather how "globalization" functions locally. The large globalization process of research that we have mentioned above is something rather different from an extension of international activities in research that can be qualified as the "internationalization of research." Rather, we need to identify the changing nature of the research activities in a multipolar world that is not just the outgrowth of a quantitative increase of research. In other words, there is a change of paradigm in the way research is undertaken; it is no more a by-product of extending the research activity into an international arena, adding up more resources (more money, more human resources and also more institutions); rather, it is a definition of the research activity since its very beginning, when research programs are defined from a worldwide point of view rather than a national point of view, which is apparently a paradox; the more globalized activities thus seem to be the more locally rooted. By way of consequence, the more deeply rooted the research activity locally, the more far-reaching it could be. Or, at least this is our claim.

We titled this book *Knowledge Production in the Arab World: The Impossible Promise* because local activities often reflect global and international activities, as if the later were an impossible target to attain. Research activities are demanding, not solely because of the resources needed for their performance, but also because of their connection to scientific and extra-scientific interests. The mandate to attain a "knowledge economy" is implicitly a mandate to forget about the societal problems and challenges and make the activity visible internationally, no matter the cost. Here, we will shed some light on the status of the research in the Arab world. In the absence of some rooting of the research locally, it can just become the door for more "exits": pure and simple brain-drain, and poor research performance in universities and research centers. Research locally will be, under these conditions, an impossible promise.

2 Knowledge society/economy: the impossible promise

We began this research as a regional project, and Egypt was one of the countries we initially wanted to examine in-depth. "We are not in modernity," was the statement of an Egyptian colleague some four years before the 2011 revolution when talking about research. He was expressing, in this way, the fact that research was absent from any policy consideration. The country had left aside all reflexive work on how and why it should produce scientific knowledge. This commonly made statement was also accompanied by a reproach: "why are Egyptian researchers not taken seriously?" Was it that the country in fact impeded developing research? One can see that is largely not the case, but the research system had come to a halt in these years (Bond *et al.* 2012). An example can be read in the work of Kyriaki Papageorgiou (2007) on the development of biotechnology in Egypt, where she shows political difficulties that impeded the development of European scientific collaboration in Egypt, although US cooperation had forced changes in the legal intellectual property regime more convenient to enterprises. The Mubarak reign left feelings of discomfort among fellow academic colleagues at the University of Cairo. The stress on the university system was enormous: lack of funds, inappropriate structures and bad management. All that made the public research institutions almost paralyzed. Egypt seemed like a showcase of the disastrous situation we mentioned above. While some research fields were finding their way, as we show in the ESTIME project,[4] a revolution happened in the meantime. We cannot but be convinced that some of the dry tinder that fed the revolution can be found among the frustrated academics and students. And, when we began a second project in 2012, based on the same ambition to describe the state of knowledge production, this time in Lebanon and (to lesser extent) Jordan, our aim was to understand the dynamic of research, as we will explain later, and not only its institutional setting.

In recent years, research and analysis on knowledge production and innovation in the Arab region has grown. Probably, this was triggered by the first Arab Human Development Report of the UNDP (UNDP 2004 & 2005), which stressed the need for better education, freedom of thought and more adequate jobs in Arab countries. Thus, the production of knowledge was put on the agenda, and joined, not unexpectedly, the interests of enterprises, promoters of a more competitive economy and the World Bank in the promotion of a knowledge economy. Thus, the issue was no longer only that of expanding awareness of the importance of knowledge in society, but that of competitiveness of the Arab economies, through the promotion of a knowledge economy. Research appeared to be one among other "pillars" that needed to be constructed in order to accompany the entry of Arab countries into the knowledge economy. These claims are so broad because they are based on macro-economic assessments, themselves "empirically" founded on broad indicators with little to no understanding of the research dynamic. Essentially, they are grounded on a thin theory of development – a theory that is basically void of political forces, with a vision of a consensual and uniform society, where competition is an individual contest on a single ladder that goes to the top. Rankings and knowledge economy go hand in hand, and the knowledge economy could thus grow under authoritarian regimes that seemed to do quite well on this part. Tunisia had to follow the example of Finland; the Gulf countries were showing the way by growing rapidly in terms of the knowledge economy and the index of competitiveness. Unfortunately, this view is to be found in practically all recent reports on research in the Arab countries. They include a *promise* for development based on a sort of miraculous inclusion into the knowledge economy. But then Nokia fell, and Finland was no longer a good example; the Arab countries had the curious idea to perform revolutions instead of seeking the competitive advantages they were told to pursue. Ben Ali flew to Saudi Arabia, and a long process of reform and revolution (what Asef Bayat calls "refolution") seized the Arab world (we examine the discourse about this fundamental change in Chapter 8). Quite conscious of this extraordinary political change, the World Bank repeated, practically unchanged, this *impossible promise* by publishing the report "Transforming Arab Economies: Travelling the Knowledge and Innovation Road" (Center for Mediterranean Integration 2013). The only thing that changed in this report was its milder tone! Again it is a clear proposition to enter the knowledge economy, and again the real revolution that had occurred just two years before this publication is absent.

Perhaps prematurely, Arab countries – or rather some actors inside the Arab countries, mainly government officials – have wanted to be called "knowledge societies."[5] Every country appears driven by the need to become a "knowledge economy,"[6] a title that became popular since the 1999 World Bank report (1999), and that was actively promoted by the knowledge assessment methodology designed by the World Bank, and specifically targeted to the MENA region (Reiffers and Aubert 2002). Building a knowledge economy became a policy objective alongside, and sometimes in contradiction with, the goal of establishing national innovation systems. The concept of a knowledge economy was formulated by focusing on some aspects of the developed economies that enjoy a dense network of research institutions, a high degree of investment in research and development (R&D) in both public and private institutions and a strong infrastructure, known, since the rise of the digital age, as "knowledge infrastructure" (Bowker 2001). This is sufficiently true for the United States and other G8 countries with the importance of what Richard Florida (2014) calls *the rise of a creative class*. Knowledge is about using information, not about mere exchanges of information; it is a practice rather than a possession. Knowledge infrastructures and knowledge circulation would then need to have previously constituted the social and economic conditions that would favor knowledge creation, a task that goes beyond promoting more exchanges of information, or inducing more young people to join creative companies.

Curiously enough, the "knowledge economy" was proposed by the World Bank (1999) on the basis of a comparison of the trends in Asia and Latin America, which was under the direction of a Bank official based in Mexico City. Probably one of the very first authors who wrote about the "knowledge society" was Nico Stehr (1994). He noted that, as a result of the remarkable growth of science and technology in modern society, it had undergone a fundamental shift and become an immediately productive force. Technology was no longer a "cultural" product, but a basic ingredient of any sustainable, long-term economic strategy. The closeness of science and technology that research has uncovered is here to stay, and will run ever deeper in social and political decisions. As many scholars from different regions have shown, a new set of institutional capabilities is deployed everywhere (Valenti *et al.* 2008). Yet, beyond glorifying the word "knowledge," there has been little reflection of these changes in the Arab region (Arvanitis and M'henni 2010).[7]

We could summarize how the knowledge society discourse has been projected in the Arab world as follows: the UN/World Bank ring alarm bells concerning the situation of knowledge production, but at the same time they adopt a methodology and indexes that cannot help the Arab world in how to create knowledge that is useful to their political and socio-economic status. This methodology is based on four pillars of the knowledge economy framework: first, an economic and institutional regime to provide incentives for the efficient use of existing and new knowledge and the flourishing of entrepreneurship (this is often based on the leaders' opinions); second, an educated and skilled population to create, share, and use knowledge well; third, an efficient innovation system of firms, research centers, universities, consultants and other organizations to tap into the growing stock of global knowledge, assimilate and adapt it to local needs and create new technology; and fourth, information and communication technology (ICT) to facilitate the effective creation, dissemination and processing of information (see Figure I.1).[8]

As Tremblay (2011) reminds us, Arab countries have rarely developed typical knowledge economy industries, such as production or assembly of electronic components, biotechnology or pharmaceutical industries. Ali Kadri (2014) talks even of policies of deindustrialization that have laid to waste the production of knowledge." The indexes used for post-industrial society (Bayat 2010) do not fit the reality of many Arab countries.[9] Two examples may show methodological and/or data collection problems. The ICT indicators for Tunisia showed positive

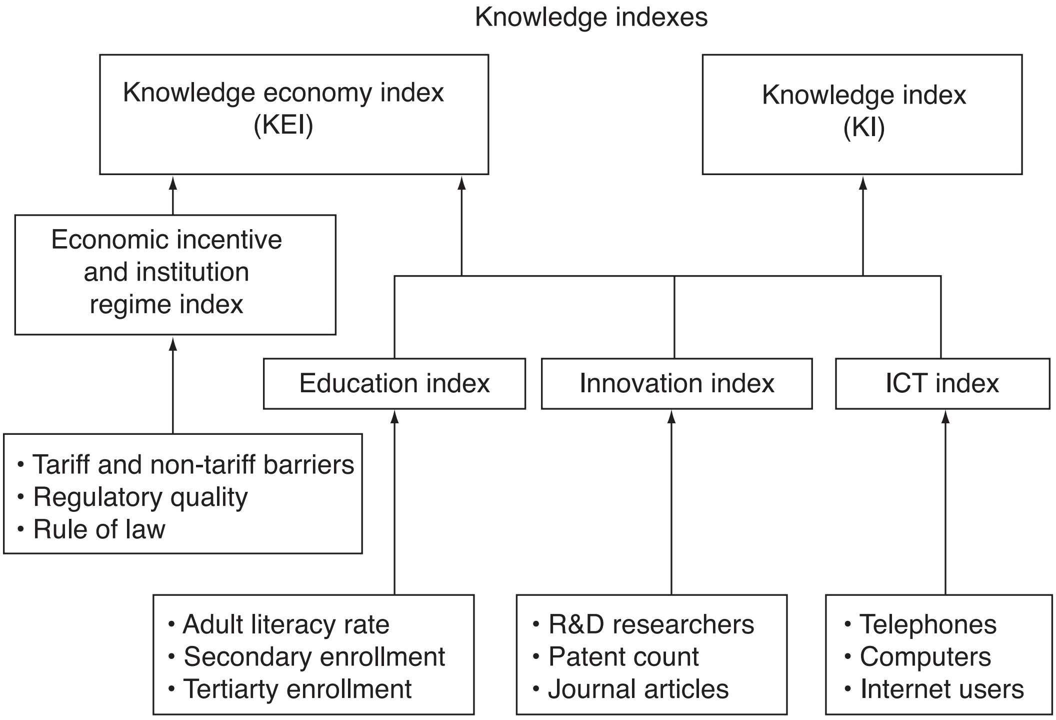

Figure I.1 Knowledge indexes (source: World Bank http://siteresources.worldbank.org/INTUNIKAM/Resources/2012.pdf).

progress in the early 2000s. During that time, Ben Ali took over the internet from the very prestigious research center the Regional Institute for Computer Sciences and Telecommunications (IRSIT). ICT ranking is not sensitive to the state repression, surveillance and filtering; it even tends to favor countries that apply these repressive technologies. The second example is related to the innovation leaders' opinion surveys and ICT; these surveys conclude an advancement in many Gulf countries ranked better than Lebanon. This claim is wrong, as we will show in Chapter 4 (see also Kumar and Welsum 2013), mainly because it equates development to the opinions of some leaders in enterprises more interested in getting access to world markets than in the local economies' growth. Finally, one of the major effects of the "knowledge society" discourse is to legitimate policies, as was the case with the promotion of the concept of good governance by the World Bank, when it was used as a word that permitted avoiding the use of the word *democracy*, seen as politicized. So far we don't know if the knowledge society discourse is just a mask without real effect, or if it will, somehow, trigger some unintended effects. It is not anecdotal to mention that in Saudi Arabia, the Center for Strategic Studies of King Abdul Aziz University launched a series of e-books[10] on the knowledge society, in which we were positively surprised to find that while writing on the contribution of Saudi women in research, the author alludes to the violation of women's rights in this country. It is too early to see how society will benefit from such discourse to "reform" society and produce a critical thinking-based research.

We have tried, as have others, to keep an optimistic view about the future. But hiding the situation by the ritual invocation of the "knowledge economy" or the "knowledge society" as a solution to the problem of research is nothing but a rhetorical tool. We, as social scientists, cannot but convey this permanent feeling of unfulfillment that our colleagues express in their own words when they blame a "brain-dead country" (!), the inadequate procedures and the short-sighted policies. Although not unanimous, these negative judgments are quite common and contrast strongly with the positive and political platitudes served by governments concerning research: that we should triumphantly enter into the new knowledge economy, leaving behind us under-development, and embracing willingly globalization and its benefits! (See such discourse in Center for Mediterranean Integration 2013). Beyond the resources issues, engineers and economists are challenged to accompany this change while political challenges are still very important, including the democratic ideal that was behind the nahda (Arab renaissance).

Even worse, social sciences have no part in that; national councils and ministries are very cautious in dripping resources by small amounts such as to justify support for social sciences and thus not be accused of barring the research support against social scientists, and simultaneously pretend social sciences are not "of the same nature" and thus do not "really" participate in the research environment. Social scientists themselves have done little to overcome this state of affairs. Social sciences are still very fragmented (with interdisciplinarity not yet to enter into the Arab world), while the scientists publish too little, reject the collective and teamwork and are seeking simply to survive in the university system. To our knowledge, the Arab Council for the Social Sciences is one of the very few initiatives that seeks to overcome all these issues and create a funding scheme that can appropriately benefit the social sciences. The diagnosis concerning the social sciences is rather worse than those of the natural sciences: it often relates excessively to the political engagement of its members at the expense of the content of their research (and sometimes the opposite: technical social science with no political soul). It relates to the way social sciences are barred from being a research domain and is still very much thought about as "intellectual work" of some kind (presumably different from that of an ecologist or a physicist) or as a political and ideological activity.

Strangely, as we will show, research (even in the social sciences) may still be a marginalized activity in the Arab world, but scientists in the Arab world today are more likely to be equivalent in training and social profile to their European or American counterparts. In retrospect, from 20 years ago this is an extraordinary change, as compared to the situation in the mid-1990s (Gaillard and Schlemmer 1996; Gaillard 1994). Thus we have a paradox well-illustrated by a Syrian professor, an engineer in material sciences, who told us back in 2007, after having spent 12 years in Japan: "I have produced 12 high-level peered articles in twelve years in Japan; today, I am closing twelve years in Aleppo since I came back and I have not been able to publish even one paper!" So the environment is what makes the difference. And the research environment is the most important subject of this book.

3 Understanding the practice of research

Research as a social activity needs to be recognized politically, since most of it is public or publicly funded. Before going any further, it is essential to remind readers that this is not a default proper to “poor” countries as is hinted in some international reports that underline with a suspicious insistence the low level of private funding. A majority of research has always been public, whereas development (or R&D) in firms is usually privately funded. In Europe, the share of publicly funded research is higher than in the United States. However, the extent of this varies from country to country. In the rest of the world, large variations also exist, but research is mainly funded and performed by public institutions. This is also the case in the Arab world.

Most of the original and breakthrough research is public: infrastructural work and the surveillance economy that is needed to monitor local resources require levels of investment that no private firm is willing to fund (but will gladly share). Even the most profitable and commercial private firms developed new technologies that come directly as a result of public programs (Mazzucato 2013). These reminders are necessary because many voices call for a strong participation of the private sector; however, it is also necessary to keep in mind that the private sector will never fund the so-called basic research.[11] Thus, politics, plain and common as they are, play an important role in the game. Jean-Jacques Salomon (2001) points out that it is not because it concerns science that science policy is any more “scientific” than other public policies. Indeed, science (and technology) policy is as messy as any other policy: it relies on political work, political alliances and the use of scientific activities as political resources. Failing to recognize this political nature of science policy comes from a bureaucratic vision on what science is about.

There are two aspects that deserve our attention on this front: the political standing of science inside the state, and the relevance of the activity itself.

Roland Waast (2006) urges us to examine the political position of science when he mentions the need for a “pact” that elites can establish between them and with the political personnel in order to develop research – a rather strange and remote activity that seems to be far away from everyday life. The political forces and the institutional structures within a country should reach an agreement. A country where internal disagreement is strong will be less prone to develop this inside-the-walls obscure activity that serves no immediate and visible purpose. Marcel Antonorsi-Blanco and Ignacio Avalos (1980) wrote some famous pages 35 years ago mentioning that science is interesting only when it allows one to inaugurate some libraries. Most importantly, Mouton and Waast (2009) have shown that the reasons why some middle-income countries actually give priority to research does not rely on GDP, investment or any other resource; rather, it depends upon a political choice. When research becomes part of the arsenal of wealth and power, then it is given some attention. Of course, that is an indication of which research areas will be favored by state policy, areas that will be shown in Chapter 2 when we study the development of specialization patterns for each Arabic country.

So, what is research useful for? This question relates to another one: Whom does it serve? We would rather tackle this second issue here, by focusing on the particular question of the *relevance of scientific knowledge*. It appears to us that this is an issue at the very heart of the relatively marginal interest for research in Lebanon, Jordan and more generally in the Arab world. It is the issue of the relevance of scientific activity that crystallizes all discontents: everyone has a solution for science and why and how it should be, and how it should be useful to development, modernization, integration of the world economy, whatever you name as grand national objectives.

We follow the tracks of Antoine Zahlan, who is a long-time observer of scientific development, and his recently published book (2012) that not only underscores a general move toward more scientific activities, as we all do, but also carries out a reflection on why scientific research should be developed. Zahlan's book, like many assessments, calls for more research and innovation. This is based on a diagnosis of the low intensity of research, and is accompanied by a wish that science and/or innovation will ultimately become a matter of priority for the Arab states. Zahlan quite bluntly states that not one Arab country has ever given science and technology a chance, despite the rhetoric about the necessity for science. He also states that the issue is related to the fact that science does not serve any strategic objective like defense, feeding the people, guaranteeing their security or supporting their economic activities. He insists that science and technology should be recognized or the sovereignty of the country could be undermined. While he is interested to understand why the research has been marginalized so strongly, he fails to investigate why it happened this way.

In this book, we make a claim not only about the necessity of research, but of research that has neither direct economic objectives nor "strategic" objectives. Research that is curiosity-driven is a major ingredient for the future. It can lead to fundamental breakthroughs and indirect economic advantages. It can lead to unexpected results, or to a dead-end, but failure, in this case, can be a major breakthrough since it obliges us to re-open other basic avenues. We seem to repeat an old song here, and in reading it young researchers might find these old-style and démodé claims of university professors that just defend their corporation. However, in the Arab world there is a sort of mantra of pragmatic usefulness that has also fed the idea that the future will be "engineered," that translates also into a good deal of useless research, not unlike many other countries in the world, that does not favor creativity and a critical stance. Our claim is that the research we have been seeing in most of our interviews relates rarely to path-breaking work not because of a lack of resources, but because of lack of audacity, lack of organization and lack of independence. As Louis Pasteur said, chance only favors prepared minds. Alexander Fleming would never have found penicillin if he had not been actively engaged in searching for an antiseptic. His cultures were contaminated by pure chance, but the identification Fleming did later of the anti-bacterial effect of this specific substance was anything but chance. It was systematic research and openness that guided the researcher in a path paved by previous similar discoveries. Serendipity, this curious phenomenon that produces simultaneous inventions, unexpected results and amazing innovations, produces immense social and cultural benefits (see the beautiful book of chemist Jean Jacques (1990) called *L'imprévu ou la science des objets trouvés*). Some of these benefits, although difficult to measure, are quite straightforward: the first and foremost result is attracting young people to research, increasing the awareness about the fact that not everything can be bought outside our frontiers, and that genuine and original research is ground for powerful economic, political and cultural independence. There is also a strange, often implicit, belief that research that is not useful should be left aside: urgent tasks for the development of the country should lead the way. Why is it that non-hegemonic countries shouldn't enter into these areas of research that have no immediate relation to development? And, since all this is about judgment, who is the authority that decides what is useful or not?

We believe this last question is the crux of the matter: funding decisions, recruitment, publication, awareness and technology transfers are activities that relate distant interests and different social worlds. The power of research is the fact that it creates linkages between socially different worlds: different social classes, different locations, different places, different interests and different objects. This is a very powerful tool and not only does it create bridges among different sides, it also invites us to think differently about development itself. None of these aspects can be observed other than by focusing on research practice.

And it is exactly what this book intends: to investigate some of the research practices in the Arab world through the case of Lebanon. We are also particularly aware of the situation in Jordan, where we have had many interviews, particularly in the social sciences. We have also examined the institutional situation of the Arab countries. The objective here is not to focus on success or failures, but to depict the Janus-like face of Arab research, poised between the negative and the positive, faced with two potentially opposing strands: the local relevance and its internationalization. We would like to critically assess the role and dynamics of research, not perform an evaluation.

In the Arab world, most, if not all, countries failed to undergo the policy changes we are mentioning here. Neither the institutionalization of research, nor the scientific community formation seemed to have been taking place. Social and political issues have often not revolved around scientific research; worse, research has often not really integrated any of the local social and political issues. Even if we exaggerate a bit (as we will show, mainly in the second part of the book), most, if not all, of the "hot" issues in science, be it natural or social sciences, were developed outside the frontiers of the Arab nations. Known for their originality, few scholars, including European descendants and the European immigrants to the Arab world, were recognized for their interest in the local conditions. If a bright young Arab PhD student finishes his studies in France, the best choice is either to stay in France or change profession and get out of academia. The mostly authoritarian regimes applied a continuous process of reinforcing heightened pro-development policies, were blinded to the university environment, restricted themselves to short-term policy objectives, under-funded public laboratories and repressed reflexive thought and freedom of expression. Sparse cohorts of highly trained personnel engaged in public organizations as a unique means for research. Most of the universities were never seen as the locus for research either. And, meanwhile, there was no construction of a scientific community, which was neither socially nor politically recognized. When these groups were created, it was always along disciplinary lines, with weak internal social exchange mechanisms (journals, meetings), haphazard international collaborations and sometimes even lack of recognition of research practices inside the training institutions (schools and universities). The effect of all these phenomena has been devastating; most Arab countries have become blind to the circumstances occurring around them and even inside their own societies and their own natural environments.

As mere reflections of the Arab revolution, universities and research centers have also heard urgent demands, such as employment, more freedom of speech and an increased scope for practice. To commit to such, we repeatedly hear demands about the need for better governance of the research systems. Slow administrative processes, heavy bureaucratic burdens, corruption, unclear methods of management and opaque decision-making processes are part of the institutional structure of the research-performing units that are manifested in the university systems. They translate into inadequate management procedures that affect directly research, especially inside universities.

4 Some interrogations and choices

The time is right to understand why this absence of reflexivity. Research – or rather the absence of research – has left a profound wound that will take many years to heal. Our proposed remedy is to trigger a wider reflection on the status of research in the Arab countries, beginning with Lebanon. We do not focus on "science," nor "innovation" nor "knowledge economy," but only on how research is working.

We adopt a national perspective (we will sometimes refer to the research systems of the Arab countries),[12] although the dynamic of research and innovation is not only related to national policies and national frontiers, it is a dynamic dependent on many social actors directly or indirectly involved in the development of scientific activities that work at the global or national level, according to their own needs, perceptions and objectives. Their logics of action may thus be different, divergent, or in direct opposition to one another and are observable at the local (and national) level where programs effectively translate into actual work.

We are also interested in scientific collaborations, an instrument through which research has grown locally; also, through which the training of future researchers is done. Research has always been an international endeavor based upon international collaborations. They play a structuring role in countries with scarce resources, less historical experience, or less diversified research systems. Collaborations seem to be a founding element of a local scientific community, along with a more localized effort to structure disciplinary fora, publications and management of resources. It is thus always by seeking to maintain this tension between what is recognized internationally as a valid interrogation and what is the more localized need that research is constructed. Institutions play an important role because they maintain a certain continuity as they guarantee sufficient resources to permanently feed labs and teams, whereas a project-base science tends to be always "on the go" by seeking funding opportunities. Academics and scientists thus act as geo-strategists in their respective disciplines by identifying main actors and possible collaborations. In addition, they act as entrepreneurs of research by managing permanent resources which include personnel, PhDs and post-docs, money and information.

In the scope of public health, manufacturing innovation, biological and other natural resource management, or pollution, there is not one issue that is clearly not global. Questions which include access to anti-retroviral medicines, or intellectual property disputes over global technologies, or disputes over the management of local knowledge systems (e.g., in natural products with pharmaceutical action) or biodiversity resources are fundamental issues involving human security, energy, food security, environmental degradation and desertification, and demand local solutions draw upon global knowledge resources. To do so, these resources are all developed and accessed through research. Therefore, a non-existent research structure misses the ability to manage the issues. Research also plays a key role in international fora where standards defining legal codes, security, health and trade regulations are debated and established. Membership in the exclusive club of those proposing norms and regulations at the global level is determined by research. All these reasons make really urgent the development of research in the Arab world.

Non-hegemonic countries, as mentioned before, have a very minor role in the global "agenda" setting for research. It is important to keep in mind that there inherently exists an agenda for research, which is always political; ultimately, influencing how knowledge is created, used, and disseminated, a process that is still not well understood in the Arab region. Because of the globalized nature of scientific knowledge, an active research structure requires the development of multilateral linkages, involving centers in different countries. Until now, various new institutions, for example those mentioned by the Arab Knowledge Report, have been national endeavors with little multilateral cooperation. This relative isolation is a symptom of lack of sufficient confidence, in all senses of the word, and from all actors involved.

To understand how the issues can be turned into a research and innovation agenda, we focus on the conditions of knowledge production, dissemination and use, by looking at the nature of existing problems in academic life inside universities and research centers of the region. When it comes to innovation, it is even less understood because of the scarcity of studies on what effectively happens inside private and public economic sectors.

In order to understand that, we will rarely use the word "*science*" as our interest lies in *research*. We are indeed interested in the study of research in the making. As Hebe Vessuri *et al.* (2013) reminded us, we need to frame the discussion in terms of a transition from the culture of "science" to the culture of "research." For Vessuri, research and society today are entangled to the point where they cannot be separated any longer. For this reason, we opt to study the research practice in Lebanon and not Lebanese science, which is the practical activity of doing scientific research and not how its results become stable "as a science." As Bruno Latour (1987) pointed out, "science" is cold, straight and detached, whereas "research" is warm, involving and risky. Science puts an end to the vagaries of human disputes, research creates controversies; science produces objectivity by trying to escape the shackles of ideology, passion and emotions. Ghassan Hage (2013) adds that Latour sees research to "capture" and to "extract" knowledge as part and parcel of the very apparatus of capture and extraction that constitutes modern capitalism. He, therefore, invites us to think more carefully about the kind of reality in which research is enmeshed and about the possibility of writing and even performing research differently.

With these choices, we also would like to insist that opportunities for increased research activity will never be the outcome of research "on its own," "for its own sake," just because of the mere increasing of numbers of academics, or through the organic growth of the academic sector or simply increasing entrepreneurial activity. Mouton and Waast (Mouton and Waast 2009) show that many reasons explain this development of research activities, such as historical precedent, the role of the state, the relation of the state to its scientists and to the use of knowledge in the state apparatus, the type of development strategies (and to what extent national development becomes an objective) and trust in science. As we also mentioned above, it is also related to how elites view science. Investment in research and innovation is a policy choice, and in non-hegemonic countries the active decisions of the state influence more profoundly these choices than countries with multiple actors engaged in research and innovation and broader historical commitment to research.

5 Sources and methodology

This book is the outcome of a long reflection on the status of knowledge production in the Arab world by the use of not only empirical observations, but also historical-structural analyses. In addition of bibliometric, empirical and desk research, we have longstanding experience in this field as a researcher and participant observers.

Rigas Arvanitis has developed programs on the dynamic of research, the links between research and production, the rise of scientific communities in the developing world, the international collaborations in science, the study of technological learning and innovation in firms. He has worked in France, Venezuela, Mexico, China and the Arab Mediterranean countries (17 years permanently outside Europe). Sari Hanafi, as editor of *Idafat: The Arab Journal of Sociology* (Arabic) and a member of the editorial board for many Arab and international academic journals,[13] has overseen a large number of social science manuscripts.

Also, by being a faculty member at AUB, he draws on many arguments grounded in his experience and by doing so this university is considered for this book a special case study. Also, as director of a research center – Center for Palestinian Refugees and Diaspora (Shaml) – he was exposed to policy and public social research. Being vice president and a prior member of the Executive Committee of both the International Sociological Association and the Arab Council of Social Science familiarized him with issues related to the formation and institutionalization of the scientific community. We should admit that this native familiarity with the universe that we analyze was thus an asset, but could also be an obstacle that we had to overcome.

In preparing this book we relied on a long desk review of existing country studies in research and innovation in the Arab region (Hanafi and Arvanitis 2013a) and a strengths, weaknesses, opportunities and challenges (SWOC) analysis (Hanafi and Arvanitis 2013b). In this manner, we systematically reviewed most information on research policies and research institutions. We also reviewed available science and technology indicators and we examined the question of data in the region.

In addition, we conducted the following surveys, whose methodology will be detailed at the beginning of each chapter:

- In-depth interviews in 2009–2010 in the Arab East (Egypt, Syria, the Palestinian territory, Jordan and Lebanon) with 23 social scientists about their authorship practices and their participation in the evaluation of colleagues with regard to promotion.[14] Interviews were organized around accounts of personal stories of research and publication, the importance of writing, the different tasks undertaken in the research process and the decision-making processes of journals.
- We underwent a complete analysis of the policy framework in Euro-Mediterranean cooperation. We examined all documentation provided through international negotiations that R. Arvanitis had participated in and were publicly made available. Moreover, as head of the ESTIME project, Arvanitis has reviewed a series of research policies in the whole Arab region (Arvanitis 2007).
- 203 CVs of scholars from Egypt, Jordan, Syria, Lebanon and the Palestinian territory were broadly studied in 2009–2010. These CVs were collected over the last four years through research on university websites, together with consultants' CVs provided by the UN human resource department, as well as from those who submitted manuscripts for publication in the journal *Idafat: The Arab Journal of Sociology*. We use these CVs only to look at the language of publication, the outlet of publication, the ratio between published articles, newspaper articles and unpublished reports, and finally at participation in conferences, workshops, public and academic talks. This "sample" cannot be considered in any way representative of the Arab East social scholarly community, and therefore we do not use percentages in this analysis.

- Online survey by questionnaire that serves the purpose of organizing the issues at stake. The 27-item questionnaire survey concerned the use of references in PhD and Master's these, and was answered by 165 people who hold a Master's or PhD degree from a university in the Arab world, regardless of discipline.
- The syllabi of 30 social science courses taught in Université Saint-Joseph of Beirut (USJ), the Lebanese American University (LAU) and the American University of Beirut (AUB) were analyzed.
- A systematic random sample of 225 op-eds in 2010–2011 to determine the importance of the contribution of academics to editorials, compared to other categories of authors. Three Lebanese newspapers were chosen based on a combination of high circulation rates and robust national and regional coverage (*Al-Akbar*, *Al-Nahar* and the *Daily Star*). In addition, we increased the number of analyzed op-eds published in Lebanese newspapers by targeting academics appearing in the last three years (2011–2013) in the same three newspapers, as well as four additional newspapers. In total, 147 op-eds authored by Lebanese scholars were studied.
- Survey based on semi-structured in-depth interviews focusing on the biographies of a sample of 125 professors/researchers in Lebanon (respectively 50, 42, 23 and 5 from AUB, LU, USJ and CNRS) and 80 professors/researchers in Jordan (the three biggest public universities: University of Jordan in Amman; Yarmouk University in Irbid; and Jordan University of Science and Technology).[15] Multistage cluster sampling was used. The questions revolved around the conformation of the scientific community, scientific pressures, role of institutions, influence of academic mechanisms (evaluation, promotion, etc.), role of gatekeepers in the publication system and social, including family, factors that directly affected the biographies of the scientists.
- Bibliometric studies on Arab publications in general and Lebanese and Jordanian publications in particular, based on Web of Science (WoS), Scopus for English production and E-Marefa. We created a publication database using available databases as well as the annual reports of faculties in various universities.
- Specific bibliometric analysis of academic articles written on the Arab uprisings, in Arabic, English and French, yielding 519 results. English references were primarily derived from WoS and Scopus; Arabic references were scarcer, primarily due to the limited availability of Arabic databases. E-Marefa, the only reliable Arabic database, yielded only 15 results, while the rest of the articles were only available in hard copies.[16] Concerning the French articles, they were derived from the CAIRN platform.
- A large survey by questionnaire within the framework of a European project called MIRA (www.miraproject.eu), answered by 4,340 researchers from 38 countries (27 in Europe and 11 Mediterranean country partners of the EU). More than 100 Lebanese scientists were included in this survey.[17]

6 The organization of the book

Combining statistical profiles, ethnographic vignettes and prosopographic detail, this book is organized into two parts. The first part is about research dynamics, Arab research systems and knowledge produced in all disciplines; the second part focuses particularly on the social sciences.

In Chapter 1 we present a descriptive analysis of research, innovation systems in the Arab region and research funding. It tests the significance of indicators commonly used in most publications about science and technology in the Arab region and provides a critical assessment. Chapter 2 delves into one of the outputs of the research – the publication – and analyzes the size, authorship and different impact factors. This chapter also has a special focus on different levels of collaboration: local, regional and international. However, as research cannot be understood without investigating both locus of research (institutions) and the researchers themselves, Chapter 3 investigates universities and national and diasporic researchers. We end this part by studying the research practice in Lebanon as a case study and partially compare it to the Jordanian case (Chapter 4).

The second part tries to locate the size and place of production of the social sciences in the Arab world and attempts to highlight the different forms of compartmentalization (Chapter 5). Then we examine the Arab sociological production through *Idafat: The Arab Journal of Sociology* (Chapter 6). This case will show the marginalization of the Arabic language, a topic we examine in more depth in Chapter 7. Chapter 8 is an opportunity to examine the interactions between scholars in the Arab world and abroad through the case of academic journal productions on the Arab uprisings. However, research is not only limited to academic production (articles in refereed journals and specialized books), but also exists in the realms of knowledge translation in policy advice or public activities. To examine the "public" social sciences, we unfold the writing op-eds in Lebanese newspapers (Chapter 9). In the concluding chapter, we draw the arguments together and consider the implications of our analysis for different stakeholders (the scientific community, policy-makers and the public).

Notes

1 For the concept of boundary work, see Gieryn (1995).
2 Sources: expenses of R&D and world publications are from observatoire des sciences et de technologies (OST) reports of 2008 and 2010. (www.ost.uqam.ca/en-us/data.aspx). GDP current prices are from World Economic Outlook (IMF) series.
3 We have delved extensively on this issue in Gaillard and Arvanitis (2013: 2) and Arvanitis (2011b).
4 www.estime.ird.fr.
5 See the first chapter of the Arab Knowledge Report (UNDP 2009), which stresses the different meanings and visions that the term entails.
6 A knowledge economy is an economy in which growth is dependent on the quantity, quality and accessibility of the information available, rather than the means of production. It is thus primarily defined by ensuring access for all to computers and the internet (World Bank 2002).

7 Antoine Zahlan, with a different wording, insists on the need to integrate more reflection in the development of knowledge organizations:

> Today the Arab countries could easily mobilize thousands of leading scholars – scientists, engineers, and doctors – to initiate high quality universities. Surprisingly, there are no tendencies toward improving higher education by utilizing national intellectual resources.... Scholarship, quality, research, and knowledge are still not prime considerations.
>
> (Zahlan 2012: 165; see chapter 10, pp. 157–175)

On Emiratis knowledge society, see Dumortier (2008: 195).

8 See the Knowledge for Development website of the World Bank. There are two indicators for performance (average annual GDP growth [percent] and Human Development Index); three for the economic incentive and institutional regime (tariff and non-tariff barriers, regulatory quality and rule of law); three for education and human resources (adult literacy rate [percent aged 15 and above], secondary enrolment and tertiary enrolment); three for innovation system (researchers in R&D, per million population, patent applications granted by the USPTO, per million population and scientific and technical journal articles, per million population); and, finally, three for information infrastructure (telephones per 1,000 persons [telephone mainlines + mobile phones], computers per 1,000 persons and internet users per 10,000 persons). For more details about KAM, see Chen and Dahlman (2005) Note that, because countries are ranked on an ordinal scale, the KAM illustrates the relative performance of a country as compared to other countries in the KAM database. As such, when a country's performance in a specific variable is indicated to have declined, it could have occurred for two reasons. First, the country's performance in that variable declined, resulting in lower values in absolute terms. Alternatively, the country's performance could have improved and resulted in large absolute values, but other countries experienced even larger improvements, leading to the country's ordinal ranking falling and resulting in a lower value in relative terms.

9 Countries such as Tunisia, Egypt and Morocco have an industry whose bulk specializes in international sub-contracting, requiring an upgrading process which is different from that prescribed by the recipe of the knowledge economy.

10 Curiously, all these books are publications without authors.

11 Counter-arguments usually come from historians of technology and from the chemical sector. DuPont's labs were seen, in the 1950s, as similar to a certain extent to academic labs. Today, no R&D unit of a good size would exist in the same form; with the changing paradigm of the 1980s came also the change of orientation of R&D units in firms (see Dennis 1987).

12 This was briefly presented in our report titled "The broken cycle between research, university and society in Arab countries" (Hanafi and Arvanitis 2013a).

13 *Al-Mustaqbal al-Arabi* (an Arabic refereed journal in the social sciences targeting specialized and non-specialized audiences), *International Sociology*, *International Journal of Contemporary Iraqi Studies*, *Global Sociology*, *Journal of Iranian Social Studies*, *South African Review of Sociology*, *Istanbul Journal of Sociological Studies* and *International Sociology Review of Books* (ISRB).

14 The time spans of interviews fluctuated between one-and-a-half hours and two hours.

15 The time spans of interviews fluctuated between one and two hours.

16 In the following journals: *Idafat*, *Al-Mustaqbal Al-Arabi*, *Majalet al-Dirasat al-Falastiniya*, *Majalat el 'Ouloum el Siyasiya* and *Omran.*

17 More details on the MIRA Survey can be found in Gaillard *et al.* (2013).

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Part I

Arab research dynamics

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1 Decisive impact of the national research and innovation systems

In many ways, the reference model for the study of research systems is the existence of a national system that includes research institutions, universities, agencies funding research, technical centers, private R&D units, "intermediate" actors such as brokers in technology and providers. Over the years, notably so because of the multiplication of studies in a large variety of countries, the complexity of the systems appeared much greater than could have been predicted on the basis of a simplistic, although systemic, view. Arab countries are also complex in their organization of research institutions and policies. Nonetheless, some constants can be drawn and this chapter presents an empirical descriptive analysis of research systems in Arab countries, with the aim to reveal these constants. We have long wanted to test the significance of indicators commonly used in most publications about science and technology in the Arab region. These indicators are employed here to develop a typology of research systems that, hopefully, can help understand the riddle of underinvestment in scientific research in Arab countries. The purpose of the exercise is to relate patterns of publication, aspects relating to the governance and organization of the research system, the role of universities, and other factors. This empirical approach is not so much interested in each country's ranking in a unique scale of values than on the characterization of their profiles, highlighting what makes similarities and differences between one profile and another.

1 Indicators and data in the Arab research system

1.1 Absence of indicators

Before describing the research systems and the factors affecting the dynamics of science and technology in the Arab region, the authors explored the indicators commonly available to public scrutiny. The sources here are less numerous. Most of the statistical information has been compiled by the United Nations Educational, Scientific and Cultural Organization (UNESCO)[1] and the Organisation for Economic Cooperation and Development (OECD)[2] and contain data for member states of those organizations. These organizations follow recognized standards for manpower and financial resources. Countries of the Organisation of Islamic Cooperation's Standing Committee on Scientific and Technological Cooperation (COMSTECH)[3] have also gathered some of these data without employing any recognized definition for manpower and financial statistics. All of these organizations necessarily rely on reporting by public authorities, but most of them do not follow the international standards or, more simply, do not really have the ability to effectively count the resources dedicated to research. Moreover, national authorities in most Arab countries have not given special attention to science and technology as part of their statistical administration.

In short, after many years of recommendations by all possible international organizations, in the Arab countries there are still no reliable input statistics; that is, data gathered according to the international standards that are defined in the "Frascati Manual," the document that contains all the internationally recognized definitions for science and technology statistics. It should be emphasized that these statistical standards have been the product of a professionalization of statistical data on science and technology. Even if they have their own drawbacks (Godin 2005), they were designed to respond to the need of a global view of science and technology and to identify the competitive status of OECD countries. The statistical infrastructure was created for this specific purpose after World War II, but most Arab countries have not been involved in this techno-economic competition that affected OECD countries. Thus, they have lacked the incentive to promote statistics of the same nature; a lack that is usually underlined by international organizations, which press them to produce uniform data. In brief, most Arab countries have had the same debate on the necessity and uses of scientific research as OECD countries, but unlike the OECD countries this occurred later in time, and competitiveness was not their main interest. It is of course difficult to make generalizations on all Arab countries, but those lacking oil, as did many countries that acquired their independence in the dawn of the twentieth century, intended to consolidate the academic institutions performing research – apart from teaching. This capacity building required crude data on the number of professors and students; as a result, more complex questions were left unattended. The richer, oil-producing countries were usually less interested in competitiveness, with the very notable exceptions of Iraq and Algeria, which were the sole oil-producing countries that defined a scientific capacity building strategy as part of their political project of independence (El-Kenz and Waast 1997). Thus, it appears that Arab countries have not had a strategic understanding of the role of research. Most recently, the debates on science and technology in society were mainly triggered by international organizations, in particular after the 2005 Arab Human Development Report of the United Nations Development Program (UNDP), which stressed the idea that research was hindered in the Arab region due to lack of freedom (UNDP 2005),[4] and triggered a very intense debate on the gaps in research in the region.

Since no reliable statistics exist on research and innovation in the Arab region, and no statistical infrastructures or institutions have been designed to produce them, it can be particularly problematic to establish international comparisons. This situation is not unique to the Arab region. Beyond Europe and

North America, only Latin America has developed a good network of observatories, called the Network for Science and Technology Indicators (RICYT), which receives regular support from UNESCO. No such network exists in either Asia or Africa, although some organizations, like Globelics,[5] have promoted linkages between units working for policy-making bodies in technology, innovation and economic development. In the Mediterranean region, because of its strategic importance for the EU, a number of networks have been promoted.[6] Nonetheless, these statistical indicators are available only in those countries that have demonstrated a political interest in science and technology at the national level, which is by itself an indicator of their focus on research and innovation (Mouton and Waast 2009).

1.2 Science and technology observatories in the Arab region

It would be unfair to say that no effort has been made to establish a reliable statistical basis for the development of science and technology in the Arab region. The Evaluation of Scientific and Technological Capacities in Mediterranean Countries (ESTIME), funded by the European Union (EU) between 2004 and 2007, was one such attempt; the 2007–2012 Mediterranean Innovation and Research Coordination Action (MIRA) included the creation of an observatory as part of its objectives. In three workshops, MIRA produced a white paper outlining plans for the observatory.[7] Experience has shown that a science and technology indicators unit would have to manage a variety of data: input data on resources (money, human resources, other resources); output data on results of research and innovation (publications, innovation, patents); and relational data, showing networks and collaborations or connections (Barré 2001). No entity of this sort has ever been created in the Arab region, capable of managing these different kinds of data. To be fair, few countries have been able to create such a unit, able to manage all of this diversity of data. What is striking in the case of Arab countries is the expressed need for such a unit by officials and the simultaneous fear to really have it. Moreover, all experts agree that such a unit should be independent from the political authorities, something unimaginable in most of these countries, where statistics and all things related to "information" are high-profile security issues. At best, they can accept including them as an office closely linked to the head of a research council, but none of the Arab governments is willing to see any such unit appear as an independent public structure; worse, the simple idea of having a non-official unit for science and technology indicators appears as absurd and senseless, since officials can only think of statistics (of any sort) as a public, that is governmental, venture.

Some countries, like Tunisia, Lebanon and Jordan, have actively sought to create observatories. Their fates are still unclear. The Jordanian project was more or less halted, and in no case could be imagined as independent of the council of science and technology. Tunisia created its national observatory and then, one year later, after a change of minister, the Ben Ali regime just decided that this was no longer necessary, relegating the unit to a simple service of the ministry;

the project has not yet been revived, although formally the observatory has been maintained as an office inside the Ministry of Research and will probably remain there. Lebanon has announced the need to create an observatory in its science and technology plan; the National Council for Scientific Research (CNRS) has launched the Lebanese Observatory on Research, Development and Innovation – and alongside it, the first feasibility study, funded by ESCWA. The Lebanese Observatory's first initiatives, including an innovation survey, science and technology survey and the establishment of indicators, are currently underway. But it couldn't create a Frascati-compatible statistic of human resources, and the figures on R&D investments are still a guess, as far as public investment is concerned, and a dated first statistical estimate concerning private R&D investments. The activities of the unit, still inside the CNRS, are also linked to political willingness. Morocco has tried on various occasions to create a structure, either inside the Ministry of Research, or the Ministry of Commerce and Industry, or inside the National Research Center (CNRST) or the Academy of Sciences Hassan II. The last attempt to date was a proposal inside a large Morocco–EU "twinning" project, that again was not followed by any results, as with all previous attempts. An ongoing private initiative might rise, finally, and this in itself should be a clear indication of the diversification of the national research system.

In the Arab region, the ESCWA has repeatedly proposed to include an indicators observatory as a support for policy-making, and it has periodically published data on science and technology. The newly created ESCWA Technology Center, based in Amman, includes an indicators unit that is focused more on specific studies than indicators of production and maintenance. At some point in the last ten years, many countries have mentioned a similar effort, but alas this was rarely translated into concrete action. When figures are (miraculously) produced at the national level, it is usually in some conference, presented by an official authority on science and technology, and one can only wonder on the light-speed efficiency of such public civil servants.

Looking at the successful experiences of countries that have developed an indicators unit for science and technology – for example in Latin America – we find that in all cases the unit has been supported by an academic team, or at least a policy-making "think tank" that is composed of academics with backgrounds in various social sciences, as well as natural and exact sciences. There is, moreover, a virtuous cycle established between (a) the fulfillment of policy objectives; (b) the provision of adequate information, processed in an intelligent way and responsive to policy needs; and (c) the production of "basic" knowledge on the science and technology community, the interaction of different scientific areas, and the productive and service sectors. The Latin American experience demonstrates the value of this close connection between academic work and the development of science and technology policy (Arellano *et al.* 2012). A similar development exists in Thailand, centered on the concept of regional innovation systems: indicators appeared as a result of the development of regional clusters of production and technology, and the governments' desire to understand and promote this economic phenomenon. Thus, in Malaysia, Thailand and China, indicators appeared from offices responsible for industrial policy-making.[8] This example illustrates that indicators can emerge as a by-product of intellectual effort to understand science and technology in the particular context of each country. That none of this has happened so far in the Arab countries is also the result of a lack of academic research on the research activities, or scarce studies on all the aspects related to the science, technology and society linkages.[9]

1.3 Composite indicators and rankings

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

Policy-makers and the literature that is aimed at business people prefer to rely on indicators drawn from opinion polls. This method relies on a survey of persons considered "knowledgeable informants," that is, professionals with particular knowledge and insight of research and innovation activities. Academics, entrepreneurs and policy-makers are asked to grade a series of variables related to different aspects of research and innovation. This mitigates the risk of false or incomplete data; nevertheless, the view of the field is reduced by the mean of opinions expressed by this collection of informed persons. Since no one can claim to have a global view of the sector, this is considered as an acceptable way to show the state-of-play. The identity of the persons responding to this kind of survey is as important as the points of view they express. Moreover, the answers obtained are measured using some ranking method which produces a "mean" opinion not necessary reflected by any real social actor (Leresche *et al.* 2009).[10] This average opinion becomes a social norm by itself; it could well be said that it reflects the demise of our capacity to modify this social norm.

A second strategy, employed by the World Bank and INSEAD's Global Innovation Index, relies on more general indicators, producing indexes and transforming the variables either into rankings or marks. This strategy also enables the creation of somewhat more robust (though less detailed) indicators. The rationale behind these complex indicators is their ability to reflect the various factors contributing to a country's competitiveness, level of innovation and so on. In its knowledge assessment methodology, the World Bank (2012) used a four-pillar set of indicators. They are: (1) economic incentives and the institutional regime; (2) innovation and technological adoption; (3) education and training; and (4) infrastructure in information and communications technologies (ICTs).

This strategy is thought to be suitable for complex issues. A similar methodology has been proposed to measure the Europe 2020 strategy for smart, sustainable and inclusive growth within the European Union, which was launched by the European Commission in March 2010 and approved by the heads of states and governments of the 27 member states of the European Union in June 2010 (Pasimeni 2011; 2012). The Europe 2020 strategy, known as the "Lisbon

Strategy," can be reduced in this way to eight indicators. Dreher uses the same method for measuring "globalization" in three dimensions: social, political and economic (Dreher *et al.* 2008; Dreher 2006). But, without any doubt, the well-known index employing this kind of methodology is the Global Competitiveness Index developed for the World Economic Forum, composed of 12 pillars, which ranks 133 economies. Technological readiness and innovation are two of its 12 pillars (Schwab and Sala-i-Martín 2012).

Finally, the European Institute for Business Administration (INSEAD) has developed a Global Innovation Index covering 141 countries.[11] This index relies on a series of indicators grouped into five input pillars of innovation: (1) institutions, (2) human capital and research, (3) infrastructure, (4) market sophistication and (5) business sophistication. Two output pillars capture actual evidence of innovation: knowledge and technology outputs and creative outputs (Figure 1.1). The Global Innovation Index is fairly consistent and we use it in our statistical analysis (see the next section).

The success of these composite indicators needs to be understood, and this would drive us very far away from our subject. In the Arab countries, it is important to remember that the very notion of a "knowledge economy" has been supported by this kind of ranking. The tacit model that is supporting this analysis in terms of composite indicators is a model of competition, since the very nature of the rankings produces comparative scales and sets the arena of the competition. The knowledge economy, as the difference of the concept from the innovation system, relies on this competitive view of the economy. Proponents of the knowledge economy will favor such a type of indicator.

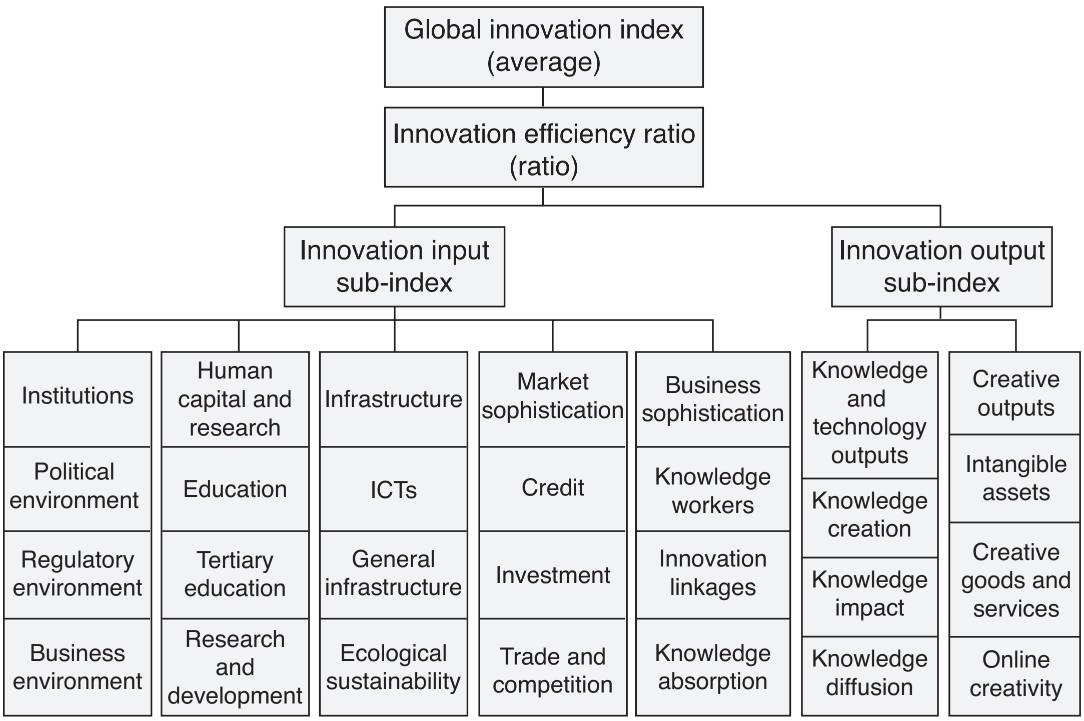

Figure 1.1 Global Innovation Index (GII) framework (INSEAD).

1.4 Bibliometric indicators and impact factors

Usually, two sources of research output are used to measure science and technology innovation: publications and patents. Both of these sources, however, rely on the existence of databases which are, in turn, dependent upon a specific social and economic system: the publication system in science, on one hand, and the patenting system, on the other hand. In the case of scientific publications, scientific and financial considerations compete for primacy in the relationship between authors and publishers. The network of scientists that evaluate the quality of scientific articles (usually anonymously) and control the circulation of ideas and scientific results has been referred to as an "invisible college," a term that recently re-appeared in the literature under the pen of Caroline Wagner (2008), where journal editors are acting as "gatekeepers." Today, this social organization is becoming increasingly complex, with the hierarchy of journals, disciplines, institutions and countries ever more difficult to disentangle. The social system of publications is further complicated by the fact that scientific publishers are, mainly, commercial ventures. Part of the debate on the validity of the impact factor stems from this discussion: it is because the structuring of the scientific community has become so diverse that no specific system or institution can claim primacy.

With regards to patents, national economic and research policies, as well as strategies developed by firms, organize the patenting system. Japan and South Korea, for instance, are very high-patenting countries in part because the patenting strategy of their firms is to register multiple patents for a single product, rather than one patent covering most aspects of an invention. Complex strategies are elaborated that take into account the cost of patenting and expanding patent protection to other countries, alongside the risk of revealing information. After all, patenting is very much more than a legal tool (Bowker 1992); it is also a way of publishing, and as such it discloses information about the technology in question. Both forms of publication, whether in academic journals or through patents, are not "objective" indicators: they depend upon strategies and social organization. Thus publications and patents do not simply reflect performance (or impact); they indicate how a society validates these outputs that are an integral part of a social system. By way of consequence, we should be careful regarding the existence or not of these "publication markets."

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 multidisciplinary databases of citations exist, produced by two major publishing entities. Thomson produces the Web of Science (WoS), and Elsevier produces Scopus. Both databases are also commercial activities as much as they are sources of information. While they are not the only two sources available for bibliometric analysis (Arvanitis and Gaillard 1992), they share the aim of being multidisciplinary and independent, and of providing information on author affiliations and citations. Scopus covers more journals and other publications than WoS. While these databases don't cover

Arabic references, there is a newly established database, E-Marefa[12] that includes academic material that covers full texts of academic and statistical journals as well as theses and dissertations.[13] However, it is still not fully operational as the author affiliations and citations index are not available in the search engine of this database (see our use of E-Marefa in Chapters 4 and 8). In addition there is Dar Al-mondouma in Saudi Arabia, which produces a quite extensive coverage of journals in Arabic language (1,249 titles, out of which Egypt accounts for 237 and Saudi Arabia for 211). It remains to examine the exact content and the uses of these new repositories.

It should be noted that new methods have been proposed for bibliometrics, focusing more on strategy than evaluation, and engaging in analytical assessment and mapping analysis (Lepori *et al.* 2008). This new way would rather insist on positioning the entities that produce the measured items. It is derived from what can be called "relational analysis," based either on words or citations, that permits depicting the relations between these items. Linkages can be rather complex[14] and a whole new field is emerging that can also be mobilized for use in the Arab region. The metrics of science, as it is called sometimes, has unfortunately too often been limited to simple indicators of a rather crude and simple type. Curiously enough, a fair amount of reflection has been given to improve *input indicators* (inputs to research being usually limited to funding and personnel dedicated to research) and to adapt them to the specific conditions of research in non-hegemonic countries, much less so for output indicators (in particular publications and patents). Jacques Gaillard (2010a) has described the general characteristics that have been changing in science and technology in the developing world and that should be taken into account by the Frascati Manual, the international reference manual that guides the collection of these indicators: increasing international collaborations, increasing international circulation of scientists and engineers, high concentration of scientific activities in some countries, profound crisis in the scientific and academic institutions and difficulties in evaluating national budgets dedicated to R&D data. But, bibliometrics, limited to the statistical analysis of publications, have been much less "adaptable," based on the assumption that, contrary to inputs used in research, publication works in the same way for all. In fact, it is largely not the case, even in the frame of one country, when comparing different disciplines. Not all disciplines publish in the same way and not all institutions promote publications in the same way. By way of consequence, not all countries support or favor scientific publication in the same way. It is not the right place here to delve into all of these aspects,[15] which have been quite often studied in Latin America. As an outcome, a society for the study of science in Latin America (ESOCITE) has been created. Here again, we can see how closely related are the academic reflection on the role and dynamic of science in a given society and the indicators that can be used to describe the scientific activity. Developing indicators in the Arab countries will require much more that simple training and stable employment of information engineers.

1.5 Measuring the impact of research

Another issue related to indicators is the measurement of the impact of research. By impact, we don't mean citation counts, but the effects of the scientific activity on society. Impact measures are becoming a pervasive topic in research policy because governments want to construct a coherent discourse on the reasons why they finance scientific activities and academic institutions. In periods of economic and budgetary constraints, parliaments and the population in general require an explanation on the expenses of the state. While after World War II the relation that existed between the state, citizens and researchers was based on an undisputed linkage, related to sovereignty and power, today this relation needs to be renewed and justified again and again.[16] The underlying political objective is neither unique nor solely defended by the state. A multiplicity of objectives and actors participate actively in both the funding and performance of research. Public research organizations need to take into account this diversity and adapt their strategies in a context of reduced public budgets.

But none of the public research organizations have any standard method to report on the benefits or effects of research on society, although the issue has been on the agenda for many years. For the Mediterranean countries, in 2011 the MIRA project issued a white paper (Arvanitis *et al.* 2013b) showing that the impact of scientific research can be measured relatively accurately at the level of a project, but this accuracy diminishes as the level is increased; thus disciplinary studies are less accurate than project studies, and country studies are less accurate than disciplinary studies.[17] The MIRA white paper concludes that impact measurement should better concern a program (that is, a collection of projects defined by the policy instruments that support it) than a discipline (since the definition of the frontiers of a discipline is always a matter of interpretation) or a country (since the scope of a policy is not necessarily national). Moreover, it showed that none of the countries that were involved as partners of the European Union had developed any public methodology or public report assessing the effects of the scientific research on society and the economy.[18]

Before entering into the analysis, we should underline that the impact of research is a complex concept that must take into account not only the disciplines being measured, but also the structuring of the scientific community that occurs by consolidating research teams, research networks and research organizations, as well as its capacity to generate new and original research projects. Measuring how new teams are set-up, consolidated and how they collaborate worldwide is the only possible impact assessment that would take into account the social dynamic engaged by the researchers and their institutions. Certainly, this kind of measurement would be more meaningful than one based on the number of citations received by a journal (wrongly called "impact measurement").

It is very strange how policy-makers, either in Europe or in the Arab countries, have resisted strongly this simple idea that it makes more sense to evaluate a public policy directed at research by looking at how teams and resources are used in a more efficient way, rather than simply counting beans – that is, numbers of papers or citations that depend so much upon both the publication system, a social organization by itself, and the existence of large, multidisciplinary databases that include citations, of which two exist today: WoS and Scopus. Policy-makers and science program managers, as well as promotion committees, selection committees and other evaluation entities, in most Arab countries seek the easy-to-apply figure that permits the university or the research organization to appear in the international rankings.[19] Moreover, the relation of the research community with society is even more difficult to appraise. The structuring of research itself is certainly not a sufficient objective and the factors that trigger a closer relation of the research with the economy and society are rarely explicitly measured, although they usually are a central motive for the research community and the public funding agencies.

So far, the Arab region has not benefited from such an exercise in measuring the impact of research activities, either in terms of the structure of the scientific capabilities or in terms of the relation of the research activities with the wider social and economic environment. Part of the difficulty relates to the fact that, although program managers are, at least nominally, interested in measuring the impact of research on the ground, they have little information on the process involved in the performance of the scientific research. Given that very few of the indicators that could measure the nurturing and mobilization of research capacities are available in the Arab countries, as we already mentioned above, it is not a surprise that "impact" has been reduced (in the best case) to scoreboards based on publications or, in the worst case, to counting "impact factors."[20] The recently published "Leiden Manifesto" (Hicks *et al.* 2015) shows that this abuse of bibliometrics instead of sound evaluation practices is becoming very challenging and undermines research.

Moreover, as we know the funding framework in Arab countries is changing profoundly, new programs are only recently defined independently of the academic institutions that host the research potential.[21] Policies to support research inside universities have been usually limited to supporting the academic institutions themselves, not any specific research through programs, calls for projects or specific scientific orientation. Universities were supposed to support research on their own, something that has rarely happened. There is some change in this regard with the appearance of independent funding agencies or funding programs among most Arab countries. Evaluation could be attached to measuring at least the impact of these new funding programs or agencies. Nonetheless, this change is still very recent and only time will tell if the change in the policy framework will induce a more permanent monitoring.

2 Mobilizing the data for a factor analysis

After reviewing the available data, we had to use most of the standard data meaningful at the national level. These macro-indicators, even if not very accurate, point in a certain direction, and show some interesting tendencies useful for our understanding of the research system. There were 114 indicators found in the literature, from a large variety of sources, and many of these were redundant. Table 1.1 provides the final list of those variables used in the factorial analysis and shows the different types of data:

- *indicators of size*, such as the number of professors, students, researchers, volumes of production (in number of articles), shares of global scientific production and gross expenditures in R&D (GERD);
- *proportional indicators* that relate science production and the number of researchers to the size of the population;
- *indicators of changes*, such as the growth rates of scientific production;
- *complex indicators* based on the General Innovation Index (INSEAD), or the assessment of R&D business investment (Competitiveness Report of the World Economic Forum), as indicated above. Their ranking (rather, the score of the composite indicator they produce) is used to complement the lack of data that exist on these activities.

Principal component factor analysis was conducted[22] to assess the underlying structure for the statistical items gathered. Before performing the factor analysis, the data were "reduced" to percentile groups in order to eliminate the distortions that could be introduced by the mere size effect, due to the large variety of scales across the data. The first five extracted factors represented 80 percent of the total variance (as reported in Table 1.2), which can be considered a very satisfactory result. Each factor is a component of the analysis that needs to be explained by the variables that are best "loaded" in this factor. The variables' representation (or "loading") in each component allow interpretation of the factors which are otherwise mere statistical constructions. Table 1.3 displays the variables and components loadings, that is, the statistical weight of each variable on the extracted factors.

2.1 Interpreting the data

Each factor can be depicted graphically. It is usual to limit the graphical representations to the two main factors, factor one being represented as the horizontal axis and factor two as the vertical axis, as in Figure 1.2, which displays the projection of variables on the plane formed by two main axes (or main components).

The horizontal axis represents the first component (31.6 percent of the total variance) and is relatively easy to interpret in both statistical and substantive terms. The component collects the variables that are *indicators of size*. It identifies, on the left side, the paramount importance given to international collaborations, as measured by co-authorships; and on the right side, indicators of scale (i.e., mass indicators, such as the number of students and teachers, shares of world scientific production, etc.). There is a direct relation between the size of a country's scientific community and the level of international collaboration, with smaller countries showing usually higher rates of co-authorship than larger ones.

Table 1.1 General list of variables used in the characterization of research in Arab countries

Gross domestic product (GDP) (in billion US$) (2010)
GDP per capita US$ (2010)
GDP per capita US$ PPP
Rank HDI (2007)
Total population 2010
Growth (%) (2010)
PPP gross national income/per capita US$ (2010)
Manufacturing, value added (% of GDP) (2010)
Value chain presence (2007)
Personal computers per 1,000 people (2009)
Internet users per 1,000 population (2009)
Knowledge Economy Index 2012 (out of 145)
EFA Development Index (EDI) (2008 ranking) out of 127
Literacy level
Percentage of literate adults
Percentage of literate young (15–24)
Percentage of students/pop that can attend
Total enrolment (2004)
Secondary enrolment (%)
Tertiary enrolment (%)
Public expenditure per student as a percentage of GDP per capita 2004
Public expenditure on education as a percentage of GDP
Public expenditure on education as a percentage of total government expenditure
Teaching staff
Total number of graduates
Gross domestic expenditure on R&D (GERD; as a percentage of GDP)
Private sector spending on R&D (rank)
GERD financed by abroad
Percentage GERD financed by abroad
Business enterprise expenditure on R&D (BERD)
BERD financed by foreign-owned companies and percentage
R&D budget/GDP percentage
Technology balance of payments
Specialized government research center
Centers at universities
Laboratories
Branch research units
Technological research cities
Global Innovation Index (GII) ranking 2012 (out of 141 countries)
PCT patent applications per million population
USPTO patents granted to residents of Arab countries 2008
Number of patents in 2005–2006
Average annual number of patents (2002–2006)
Trademarks
Academic ranking of world universities (ARWU) 2010
Expenditure on higher education (budget of the Ministry of Higher Education)
Expenditure on higher education (percentage of GDP)
Expenditure on higher education per student
Number of universities
Number of students
Number undergraduates
MSc students (2006)

PhD students (2006)
Number of faculty
Number of researchers (2005)
Local collaboration
Regional collaboration (with the Arab region)
International collaboration (2005)
Researchers per one million inhabitants
Estimates on full-time equivalents (FTEs) (2008)
Estimates on full-time equivalents (FTEs) per million population
Number of scientists and engineers in refereed journals (2010)
Number of scientists and engineers established in the United States
Number of publications in basic sciences, natural, and applied sciences 2005
Share of Arab publications (2005)
Scientific publications per 1,000 publications
Number of articles per million inhabitants (2005)
Scientific articles per million inhabitants (2008)
Co-publications (2008)
Regional co-publications (2005)
Publications in WoS/Scopus
Language of publication
Specialization index
Percentage of world shares (2004)
Growth of publications (2001–2006) in world shares
Government bodies responsible for R&D policies and coordination in the Arab region
Existence of organization of Ministry of Research, or Ministry of S&T
Coordination/funding agencies, other funding mechanisms
Document that defines the national research strategy
Type of governance in S&T
Expenses on scientific research (2005)
S&T policy document
Brain drain and rank out of 142 countries
Company spending on R&D
Quality of scientific research institutions
University–industry research collaboration
Local availability of specialized research and training services
Firm-level technology absorption
Value chain presence
FDI and technology transfer
Capacity for innovation
Quality of management schools
Availability of scientists and engineers
Laws relating to ICT
Intellectual property protection
Efficiency of legal system in settling disputes
Quality of math and science education
Internet access in school
FDI (in millions US$)

Table 1.2 Total variance explained by each component

Component	*Percentage*	*Cumulated percentage*
1	31.6	31.6
2	18.6	50.2
3	13.9	64.2
4	9.3	73.5
5	6.9	80.4

Note
We indicate here only the percentage weight of the components in total variance.

Table 1.3 Variables and components

Variables	*Components extracted from the analysis*				
	1[a]	*2*[a]	*3*[b]	*4*[b]	*5*[b]
International collaboration (co-authorship) in SCI	–0.689	0.2	–0.062	0.463	–0.001
GII (ranking 2012 out of 141 countries)	0.014	–0.445	0.32	0.698	0.278
Growth 2005–2008	0.037	0.303	0.706	–0.505	–0.18
Growth 2001–2004	0.131	0.641	0.421	0.136	0.441
Business R&D expenses (ranking 2008)	0.275	–0.344	0.046	–0.225	0.768
USPTO patents granted to residents of Arab countries 2008	0.282	–0.232	–0.824	0.085	0.008
GERD 2007	0.393	0.041	0.381	0.297	–0.302
Students 2007	0.446	–0.743	0.315	–0.221	0.085
Researchers per one million inhabitants 2007 (UNESCO)	0.528	0.57	–0.119	0.216	0.172
PCT patents applications per million population	0.572	0.522	–0.393	–0.064	–0.035
Teaching staff 2004	0.587	–0.687	0.207	–0.079	–0.116
Number of universities 2006	0.616	0.385	0.415	0.083	–0.071
Scientific articles per one million population 2008	0.644	0.488	–0.207	–0.287	0.169
Researchers 2005	0.805	0.079	0.201	0.405	–0.097
World share (Publications SCI)	0.905	–0.162	–0.13	0.104	–0.177
Publications in Web of Science (2008)	0.918	–0.154	–0.217	0.013	–0.019

Notes
Principal component analysis with no rotation of axis. The table is sorted on the values of the first component.
a Components 1 and 2 as shown as axes in Figures 1.2.
b Components not shown graphically.

But the analysis clearly separates the level of international collaboration: this means that international collaboration is the main variable that allows differentiating most clearly the profiles of the countries; the degree of connection with foreign scientists is thus of great significance.

The second component is represented by the vertical axis (18.6 percent of the total variance). As can be seen, on one side (upper part of the axis) we see the

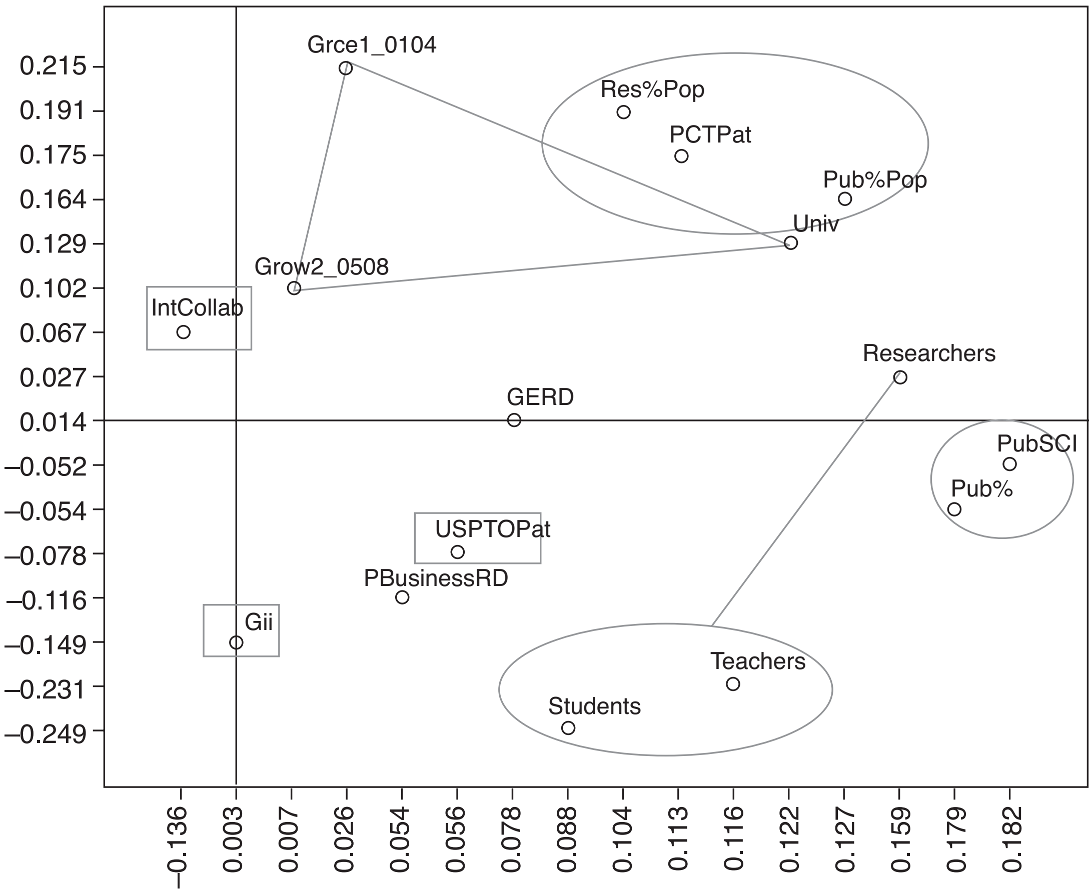

Figure 1.2 Diagram of variables.

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 composite General Innovation Index (GII) indicator, and an indicator of the involvement of the private sector (research and development business expenses as evaluated by the Competitiveness Report). Variables with less important contribution to this component are patents from the United States Patent and Trademark Office (USPTO). Interestingly, applications for patents from the Patent Cooperation Treaty (PCT), which are easier to obtain than from the USPTO, are represented on the opposite side of this second axis, which can be easily explained by the fact that PCT patents are more closely related to indicators of size than USPTO patents, which result from a deliberate strategy of firms looking for protection of their innovation in the United States. Also, many applicants first begin filing a PCT patent and, if the product and the market are worth it, subsequently file a USPTO or European patent. These indications permit interpretation of this component represented by the second axis of Figure 1.2: it shows the importance of business and innovation, on one side, and the importance of the academic system on the other. In short, the component depicts the opposition inherent in the research system between business-related drivers and academic ones (publications being the main indicator). Most of the weight in the second axis falls upon the size of the university system, larger countries being on the upper part of the second axis and smaller university systems on the lower part. In brief, the axis represents a closer relation to innovation and productive outputs as opposed to variables expressing size and growth.

The third component (14 percent of the total variance), not represented in Figure 1.2, represents the variables in a very different manner. On one side, we find simple (or crude) indicators of output (patents and scientific publications), and on the other side growth rates of publications (which are dynamic indicators of active involvement in research), the indicators or gross expenses for R&D and the GII indicator. This component distinguishes between systems that are heavy producers from those with lighter rates of production, and countries that have a dynamic growth as distinguished with the slower growth rates. For many Arab countries, which make a relatively small contribution to global scientific innovation, this has a very unique meaning: dynamism serves to balance this low production. Any explanation concerning the research system should therefore be able to satisfactorily explain both the low levels of scientific production and the dynamism (here, the Gulf countries play a significant role). Interestingly, on the "dynamic" side of the axis, we find the variable "Number of universities in 2006." Indeed, universities, in particular in the Gulf states, Saudi Arabia and Jordan have played an active role by promoting an aggressive strategy to promote research. We will tackle this issue later in the book, but it is quite clear that universities are a crucial institutional factor to be considered in any analysis of the research systems.

The fourth and fifth components represent a small contribution to the overall variance. With 9.3 percent of the variance, the fourth component compares the growth rate of publications between 2005 and 2008 to the rate between 2001 and 2004, contrasting them against the more complex and fundamental indicators of the research system (GII, international co-authorship, researchers per inhabitant). This component serves to distinguish between newer research systems in Jordan and the Gulf and the more established ones in the Maghreb and Lebanon. Finally, a fifth component (6.9 percent of the variance) opposes resources and results; on one side we find GERD and human resources, and on the other side older growth of publications (2001–2004), GII ranking, and scientific articles per million inhabitants. Interestingly, it also shows private sector involvement in research and development as a result. The validity of this assumption has been confirmed through empirical research in the universities of several Arab countries, and its significance should be emphasized: involvement in research and development does not depend upon the size of the university system. It is the result of an active policy at the university level that may be supported (or not) by the state. In other words, the movement is pushed by the individual institutions (universities in the case of academic research, or firms in the case of innovation as measured by patents). As we will show later, the innovation surveys of firms confirm this strategic orientation.

2.2 The main dimensions of the national research systems

Many messages are delivered by this first analysis. First, size indicators, dynamic indicators, and innovation indicators allow for a typology of Arab countries that we will examine here. Next to size, a research system is very much defined by the importance of co-authorship; international collaboration plays a very important role in the more rapidly growing countries but also in more consolidated research systems. Those countries with high levels of co-authorship (Jordan, Lebanon, Morocco and Tunisia) are countries with rapidly expanding scientific activity, a longer history of academic research than other Arab countries, and a trend toward consolidation of their research system. By examining the publication patterns (Chapter 2), we will reveal a specialization pattern for these countries that is more focused on biology and medicine (mainly Tunisia, Jordan and Lebanon), whereas the dominant discipline in most other Arab countries is engineering. In recent years Egypt has enjoyed a renewal after many years of relatively sluggish scientific production and an exaggerated production in the engineering field. The rate of its international collaborations has also increased, along with new growth in areas that had been largely abandoned, such as health and biological sciences, which are now gaining on chemistry and engineering. Only Algeria remains focused on engineering and material sciences, making its production profile similar to that, for example, of China.

Figure 1.3 represents countries in this same space formed by the first two axes, with each axis representing the first and second component that we just

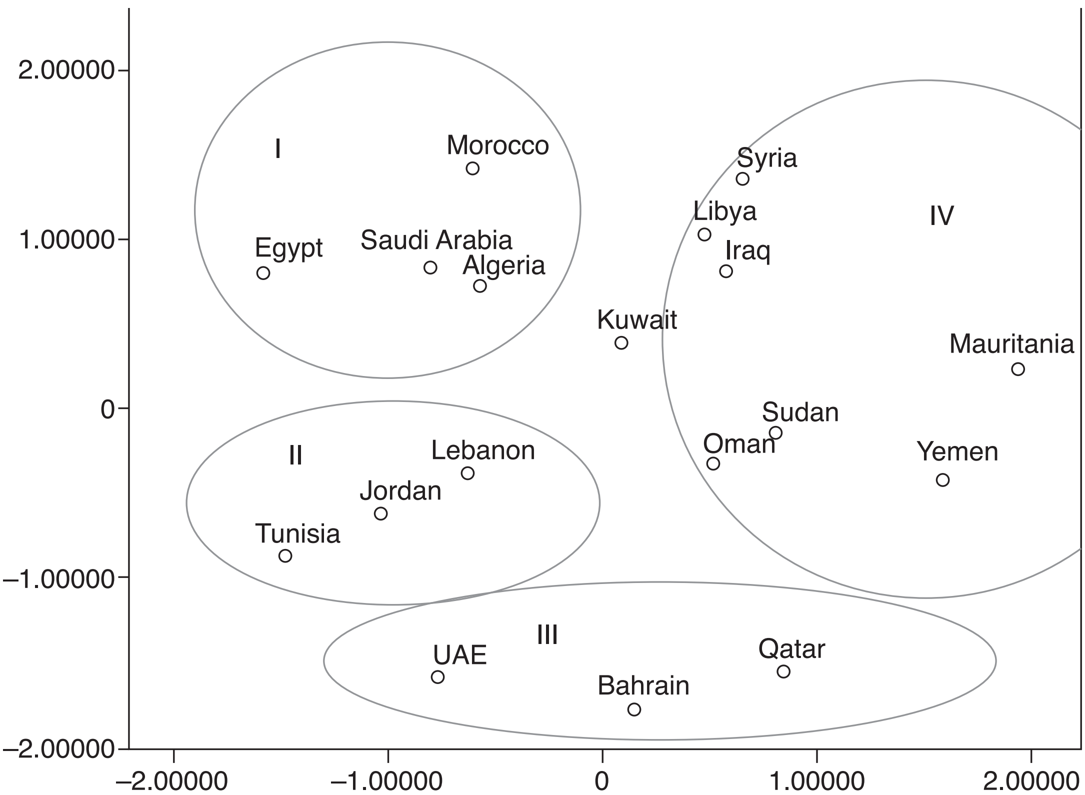

Figure 1.3 Countries represented in the space of two main factors.

interpreted above. The name of the countries is quite revealing: variables related to size (and thus, larger countries) are on the left; smaller countries are on the right; dynamic variables are pulling on the lower part of the first axis; and the size of the university system is on the upper part of this space. Driven by the second component, we see larger and more dynamic countries on the upper-left part of the graph; small and dynamic countries on the lower left part; and less dynamic countries on the right part of the diagram (the scale is not exactly the same for variables and for countries: countries vary on a wider scale than variables). Kuwait has always occupied a relatively central position on this graph, with most of its variables tending toward the middle of the spectrum; probably, its modest size but its relatively old university explains this strange middle position.

Based on these variables, four distinct groups of countries emerge (Figure 1.3).

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

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

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

Group IV All other Arab countries. It is quite difficult to differentiate between these small and less integrated research systems. Some universities seem to be developed, but scores are low for many variables. Iraq has been placed in this group, in spite of the fact it was before the 1990s one of the large producers of basic and applied science in the region thanks to its national science system (Ghafoor *et al.* 2009; Hammam and alhajaj 2014) but it has yet to engage in the reconstruction of its once well-regarded university system.

2.3 Models of governance of the research systems

Some years back, the ESTIME project intended to describe the state-of-the-art of the research systems in eight Arab countries that are partners of the EU. Among other things, it focused on the type of governance and the main visible characteristics of the research system (Arvanitis 2007), which we reproduce in Table 1.4. Four "models" of governance of research in the Arab region were identified based on the degree of centralization of the system as well as the relation to the economy and society.

This first, intuitive categorization permits introduction of the following discussion on the governance of the research systems that will consider history, centralization, dynamism and performance before proposing a renewed typology, taking into account these characteristics. Before entering into detail we

Table 1.4 Four institutional models in Arab countries based on governance models (ESTIME analysis)

Type	*Countries*	*Main features*
The Gulf model	Gulf countries	Trade-oriented governance in performing institutions National funding for research is rather centralized de facto Public and foreign universities open to foreign teachers/researchers Research based on international collaborations and few regional projects 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 and few recent private universities
The Machreq model	Lebanon Jordan	Decentralized governance National funding for research is rather centralized de facto. Numerous alternative sources of private funding. Research concentrated mainly in private universities in Lebanon and much less in the public university; main research universities are public in Jordan
The Maghreb model	Algeria Morocco Tunisia	Centralized governance for both funding and management in performing institutions Large public universities Research mainly in universities and mission-oriented public research institutes

would like to compare it to the typology explained above that was drawn from an analysis of the main statistical variables.

We can see some clear differences, mainly because the ESTIME typology does not take into account the *size of the research system*. This explains the fact that Saudi Arabia is not included in Group III above, although all the other countries belong to the ESTIME typology called the "Gulf model." What is common to all these countries in the "Gulf model" is the aggressive strategy to consolidate research by encouraging international institutional cooperation and attracting foreign researchers to the university centers. Also Egypt, a case in itself, is included in Group I above but was included as the "Middle East model" by ESTIME. Again size can explain this difference between the two typologies, and our present statistical typology is probably best fitted to the changes that are promoted since 2007 in Egypt, giving research stronger autonomy and more budgets. Finally, in our Group II above we find a strange mix of rather different, but "small" countries: Jordan, Lebanon and Tunisia. The two first are examples of a decentralized mode of organization (Lebanon and Jordan), while Tunisia is a typical centralized system, molded after the French administrative system. But, looking at the specialization patterns, these three countries are probably better off by being closely linked than the grouping proposed on the basis solely of the centralized mode of governance. Indeed, the three of them focus very much on life sciences and health, when most other Arab countries have distinct preferences for engineering sciences, as we will see in the next chapter.

3 A typology of the Arab national research systems

Synthesizing this discussion based on a comparison of the factor analysis and the more intuitive institutional models presented above, four models for the governance of research systems can be proposed, which combine the results from the statistical analysis and the political vision of the research system.

The comparison of both analyses teaches us to be careful when making generalizations. By looking only at the obvious, in this case the modes of governance, one misses dimensions that are less apparent, namely the specialization and dynamics of the research system, the growth pattern or the size of the research capabilities. Nonetheless, focusing on governance is really meaningful. It permits us to discuss the elements of the research systems that are derived from history, and are observable in today's evolution. Table 1.5 sketches briefly this synthetic typology before examining these structural aspects linked to history and the dynamism of the research system.

1 Large, centralized and dynamic research systems Size matters in research. Many have sought to identify the "critical mass" at which size begins to result in the under-development of research capacity. After 30 years of searching for this elusive critical mass, it is time to acknowledge the fact that size also translates into a certain diversification of interests and stronger expansion of the research system. When this dynamic process is underway not only because the population is large, but because the growth of the scientific activity is strong and

Table 1.5 A typology of research systems

Type	*Main characteristics*	*Countries*
1	Large, centralized and dynamic research systems	Egypt, Morocco, Saudi Arabia, (Algeria)
2	Large, centralized and low-performing research systems	Iraq, Libya, Sudan, Syria
3	Small, dynamic research systems	Tunisia, Lebanon, Jordan, Kuwait
4	Small, flexible and market-oriented research systems	Qatar, United Arab Emirates

consistent, then a dynamic research system can be said to exist. This is the case in Morocco, Saudi Arabia and, more recently, Egypt, which is undergoing a major overhaul of its research system. In Algeria, where the government has recently decided to invest heavily in research, this dynamic process is maybe getting underway, although issues that are known difficulties since long ago are still there. While all of these systems are centralized, they appear able to manage the emergence of competitive funds and favor collaborations with foreign partners. With the (very notable) exception of Egypt, they are rich countries. As was shown in the factor analysis, Morocco is the most diversified system in the sample. The remaining three countries (Algeria, Egypt and Saudi Arabia) share a very similar profile of disciplinary specializations. Nonetheless, Algeria shows signs of a strongly under-performing research system.

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

3 Small, dynamic research systems The research centers in this group, which includes Tunisia, Lebanon, Jordan and Kuwait, are characterized by flexibility in their relationship with the public sector and diversity in their sources of funding and human resources. Their most significant research production remains linked to the institutions that are able to draw international support and build partnerships with industry. The institutions within this model show promising dynamism. Universities play an important role and, more importantly, there are many universities with explicit research policies. However, these countries are also characterized by brief tenure of their professors. Most of the countries in this model fall within Group II of the factor analysis. They boast the highest numbers of publications and growth of production. They are also small by any standard, but have proportionally high figures of researchers and citation impact, and proportionally strong scientific production. As was discussed above, Tunisia is quite different in its centralized governance of the research system, which is mainly based on the recognition of university labs.

4 Small, flexible and market-oriented research systems This Group 4 is quite similar to the above Group 3, but distinguished by research centers with flexibility toward, and sometimes independence from, the public sector. They are also characterized by being rich and thus able to have a diversity of funding sources, and the ability to attract specialists from abroad. A significant percentage of their scientific production comes from universities and private centers and they are able to benefit from international cooperation programs, as well as from independent local funds in the cases of Qatar and the United Arab Emirates. The countries of this model correlate to Group III in our factor analysis (UAE, Bahrain, Qatar). They are characterized as very small, rich and rapidly expanding. Nonetheless, being "market-oriented" does not mean the private sector is more active in R&D. These countries have been emblematic of the "knowledge economy" because they have quite strictly applied recommendations concerning the privatization of research funding through the establishment of universities and the adoption of international standards. They have also tried to promote science cities that gather universities, technical centers, incubators of start-ups, etc. According to a study on science cities, these countries tend to be very responsive to policy at the international level and to a large extent have followed the recommendations of global financial institutions (Khodr 2011). This conformity to a perfect model also indicates the difficulty of creating a research community from scratch. Historically, the experience of small countries is limited; for example, Singapore has also undergone this process long ago with some success (Goudineau 1990), but it had to wait for more than 30 years before science of a certain quality could be nurtured locally. Finally, not all small countries are included here (Kuwait, for example, has a rather long experience mainly based in the expansion of universities). Finally, the quite surprising case of Oman is rather more complex, basing its strategy on a smaller local science base. The complexity of turning a policy recommendation, the expansion of a "knowledge economy," into a full-fledged research and innovation system should not be underestimated. We will examine this aspect after revising some of the historical roots of the research institutions.

4 History, structure and evolution of the research systems

History shapes institutions and the research path taken by a country. Arab research centers at first focused on basic sciences and medicine.[23] They subsequently diversified their programs to include applied science and technology specializations. Over the past two decades, human, social and environmental sciences have also been added. More focused centers have been created, usually because of the availability of specific, usually international, funding; for instance, there is a focus on locally significant palm tree research in a number of Gulf countries. It has not always been the case: Tunisia has a quite impressive network of small but industry-oriented research and technical centers, copied from the French model of the technical centers that are partly funded by the state and partly by industry. Traditionally, agricultural research depended on Ministries of Agriculture, which have been quite important in Egypt, Morocco, Syria and the Sudan. International agricultural centers belonging to the network of the Consultative Group for International Agricultural Research,[24] like the International Center for Agricultural Research in the Dry Areas (ICARDA), headquartered in Aleppo until 2012, have also played an important role in structuring the research in this field; desertification, water pollution and management of water resources have been promoted through French bilateral cooperation, mainly with Tunisia and Morocco; linguistic research in the Maghreb grew out of interest in Amazigh language and historical research; the Balka research center in Jordan grew out of international (mainly British) funding of environmental sciences. Many research projects are currently being implemented through partnerships with Western industrial states and the exchange of scientific visits and training. A large series of research observatories has also been created, usually linked to a specific research institute, and these act as platforms for international collaborations and further research programs, centered around specific instruments and issues (health, environment, energy, water, science and technology monitoring, political change, demography).[25] A number of new research units, public or semi-public, are created in this way, based on a mix of availability of funds and expressed needs.

A second aspect that shapes strongly the research systems is this combination of growing number of research units, and of more intense international relations. This has led to both a diversification of research interests as well as a diversification of institutional arrangements. Since for all these countries applied research and development issues are always set at the center of their concern, the increasing academic population has always been a difficult issue for governments. Research in agricultural centers belonging to a Ministry of Agriculture has a clear development objective. Whatever the activity of the research center, its mission will be to serve agricultural development. But as academia grows, and new university research activities emerge, the fundamental mission of research is less clear to the state. And as we already mentioned, research in most Arab countries is academic research. This explains the success of the “networks paradigm,” as we called it (Arvanitis *et al.* 2010). Any activity that could show its links to economic entities, either firms or other, is welcomed. The same thing happens for technoparks, technopoles and incubators. When promoting a general economy of links between research and the productive sectors, or NGOs and other social actors, the network paradigm, which is very appreciated by managers and policy officials, in fact hides two structural aspects: a very controlled dynamism and the overarching role of the state.

4.1 Growing and dynamic research systems

The growth of research units is difficult to monitor (again the issue of indicators!). Egypt, as expected, has the largest number of research centers (14 specialized government research centers, 219 research centers under the auspices of ministries and 114 centers at universities). Much more interesting is Tunisia: there are 33 research centers comprising 139 laboratories and 643 branch research units (M'henni 2007).[26] Technological research cities are few, limited to Egypt, Saudi Arabia and Tunisia, and they have very different forms and functions. The ANIMA Investment Network is an association trying to function as a networking tool among them. There is a general trend toward the promotion of technoparks and science cities. And some new research "cities" are under way in the Gulf countries: they usually link research to an institution of higher education (such as an engineering school or university) and a hospital or business. Tunisia has had the most ambitious technoparks program, which, although not growing as quickly as intended, has nevertheless been effective in some cases (M'henni and Arvanitis 2012).

The Gulf countries have relied on this idea that research and technology can be entirely fed through the creation of innovation hubs, or specialized areas. For example, there is a Science and Technology Oasis under the umbrella of the Qatar Foundation (UNDP 2009: 188). Jordan launched the El-Hassan Science Park in 2009 (UNESCO 2010b: 256). The Mubarak Administration had created its own Mubarak Science Park (which has since changed its name), but, as we personally witnessed it, was rather a research center than a unit connecting research to the outside world. Very high expectations concerning the "useful research" for development is of course understandable; nonetheless, these efforts usually take for granted that research grows by giving more resources, and because public administrations should obey the desires of their hierarchical tutelage, namely a minister, prince, king or president. This vertical, top-down approach is the rule, and even research systems with a decentralized governance seem to adopt this rather authoritarian view of the research organization.

Hiba Khodr (2011) studied three specialized "science cities": the Dubai Healthcare City, the Abu Dhabi Masdar City and the Qatar Education City. These institutions are exemplary for the governance style of these entirely new entities that combine a hospital, schools, universities and scientific research. According to Khodr (2011: 7),

> the decision-making process was repeatedly described in all the interviews as a predominantly centralized top-down process. The presence of a vision by the country's leadership is another common denominator to the interviewees' answers to the question related to main actors involved in policy development and formulation. [. . .] These decision makers share the following common characteristics: they are in the ruler's circle of trust, they have access, they have vested interests, they have "connection with the vastness of the space, otherwise they won't see the need," they have exposure to the

> outside world, they are competent people, they are not necessarily consultants, the majority are expatriates, and they are subject matter experts who are well known in their field.

Besides being established as free zones, all the cities in the study are either subsidized by the government, semi-governmental organizations or government-funded projects. They aim to diversify the economy and, in their design and policy objectives, they also target sustainability. For that, the innovation perspective is crucial to understand the implementation process of specialized cities. Khodr (2011: 15) points out that

> A specialized city seeks to be attractive not just for the home country and the region, but also for the whole world. Being the first city to implement the education, health and environment concepts on such a large scale is important and is what is common to these cities; the specialized cities-within-the-city want to become a hub and a global benchmark. They intend to gain the so-called "first mover advantage" [. . .] where customers tend to have a preference for the pioneers while others copy their innovative concept and buy their acquired expertise. [. . .] The cities attract internationally well-founded institutions and foreign professors to staff massively the newly founded universities.

The Gulf countries were able to attract many foreign branches thanks to their generous grants of million of dollars to the endowment of their home university. Moreover, the universities are considered to add value to the city. Another common characteristic of these cities is joining 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. These cities are quite recent and it is too early to see if they will succeed in realizing their declared objectives and expected outcomes. Nevertheless, one can see a clear business orientation prevailing, linked to an authoritarian way of managing and concentrating economic and political power, and finally a certain willingness to control the whole creative process.

These new orientations are linked to a certain dynamism. It should be mentioned that Arab countries are no exception to the world changes affecting research policy. This business orientation, the rather new and consolidating role of universities, the innovation-oriented research activities, the programming through funding agencies and the world competition for competences are affecting the governance of research everywhere and in the Arab countries also. What has been intriguing in the case of most Arab countries, particularly those being dynamic, is the fact that this dynamism, which claims to rely on confidence of private actors, decentralization and closer public–private relations within research programs, triggering higher investments in both education and research, is closely monitored by the state. The factorial analysis shows that differences in growth rates between different countries, as well as performance on the Global Innovation Index, do make an important difference, something that is not only related to money by itself, although it represents the concrete translation of pro-research policy engagement. But it does not underline the pervasive importance of the states, even in the pro-business strategies.

4.2 A policy framework always centered around the state

The relation of research to the state is very central: larger countries usually have a more "centralized" science policy system. Centralization can also, however, operate in smaller countries like Tunisia. Moreover, centralization has no relation to performance. A totally decentralized system like Lebanon, an exception in the Arab region, performs as well as Tunisia, which is highly centralized. Lebanon from this point of view should be the showcase for its permanent support to research by decentralized actors, among which the state is one among others. The concept of a national council (rather than a ministry) as a central coordinating figure for science policy is an indicator of this absence of centralization. This "English" system of councils fits well with decentralized countries. The "French" system of a central state administration for both higher education and research is usual in larger countries. However, caution must be taken with this gross generalization. Egypt is, apparently, in a process of rapid "decentralization" of its science policy, following an original course that has no historical precedent in the country. It has dismantled its Science Academy (modeled on the Soviet Academy of Science) and is now transitioning to a quasi-council and program-based funding. The same goes for Morocco which, within a centralized administration, is undergoing a series of state initiatives from competing government ministries as well as from administration supported by the king's counselors. The motivation in both cases is related to a need for efficiency: the old institutions and the ministry in charge have not been particularly efficient in either of these two large and complex countries; probably this explains the changes one can observe in both of these countries, with the creation of King Abdulaziz City of Science and Technology in Saudi Arabia and the complete change of the funding system in Morocco. This need to trigger new funding mechanisms and boost research is felt even by the most bureaucratic offices. But no one seems really to give space to allow free decision-making at the level of performing teams and performing institutions. Even privately funded budgets are managed by the same controlling state machineries, or the same control-minded personnel either in public offices or private entities. Many researchers in all Arab countries, usually from internationally recognized laboratories, are asking for the creation of new decision-making processes inside the public administration rather than real decentralization. What is at stake is the existence of independent research in publicly funded institutions.

In most Arab countries, research is the responsibility of Ministries of Higher Education and Scientific Research (eight countries), Ministries of Education (three countries), and a Ministry of Planning (one country), in addition to some specialized ministries (agriculture, health, industry). Five Arab countries (Bahrain, Kuwait, Lebanon, Qatar and the United Arab Emirates), all of them small countries, show an exception to this trend, having assigned the task of research and development to relatively independent councils and academies (Salih 2008; UNDP 2009: 188). Table 1.6 depicts, to the best of our knowledge, the various institutions and governance modes in various Arab countries. The diversity is rather larger than expected, something Roland Waast (2008) had already underlined in his regional analysis of Arab countries. Moreover, the very few public entities in charge of research usually cumulated functions (coordinating, performing, funding, etc.). In Lebanon, for example, the National Council for Scientific Research (CNRS), as we will see in Chapter 4, has functioned primarily as a coordinating body but also as an agency distributing research grants on the basis of competitive calls for proposals. The CNRS also has four institutes of its own, but these are relatively small.

In most Arab countries, organizations performing scientific research are mainly attached to higher education institutions rather than being independent public research organizations. Nor is it very common to see research units attached to productive or services firm or other types of organization linked to the economic activity. It has been stated, notably in the *Arab Knowledge Report*, that this contributes to the creation of a wide gap between education and research on the one hand, and research and economic and social needs on the other. The Arab Knowledge Report, as practically all policy reports on research systems that deliver a message in favor of development, advocates for a closer relationship between research organizations and industry, agriculture and other productive sectors. Since most research is public, this would entail the organic connection of research organizations to a different ministry, as is mostly the case of agricultural research; in effect, we find an organization devoted to agriculture that hosts research and development activities, basic research and extension services, and sometimes is linked to specific training schools for the agricultural sector. This very strong specificity of the agricultural sector has been reproduced in French-speaking Maghreb countries, as well as in Lebanon (with the Lebanese Agricultural Research Institute created very early, in 1964). Egypt has also had such a specific public research organization, mainly because this fitted perfectly in the state-controlled view of research for development, where a public institution was assigned to a specific economic sector. It has less been the case in other Arab countries that have experienced more recent creation of research institutions. In the particular case of agriculture, the network of internationally funded research centers (coordinated by the Consultative Group of International Agricultural Research Centers, hosted by the World Bank), has "doubled" the activity of many public research organizations, and promoted seeds and agricultural practices related to the so-called Green Revolution. Arab countries host some of these, but the main agricultural research has relied on the national public research organizations.

In any case, the overall structure of the research in the country has less been the outcome of a unified decision-making process and rather the result of a

Table 1.6 General descriptions of research systems in various Arab countries

Country	*S&T policy document*	*Permanent policy-making bodies with national authority*		*Funding agencies*	*Other funding mechanisms*	*Type of governance*	*GERD/GDP (percentage)*
		Council	*Ministry*				
Algeria	Yes (National Plan, 1998)	–	Yes	–	National research programs National Fund RTD +	Centralized	0.25*
Morocco	Yes (Vision 2006)	–	Department of a larger ministry (since 2004)	CNRST	Various funds to support innovation: PTI, incubators	Centralized	0.8*
Tunisia	Yes (5th Plan and following Plans since 1977)	–	Yes	National Science Research Foundation (since 1989), among others	Various funds to support innovation: FRP, NPRI, PTI, Techparks	Centralized	1.0*
Egypt	No	Formerly: Academy of Science	Yes	STDF and other funds	Initiatives from various ministries: Agriculture, Industry, Telecom, etc.	Centralized	0.2**
Lebanon	Yes STIP = Vision (2006)	Yes CNRS	–	CNRS since 1962	Performers get contracts from all sorts of sponsors	Decentralized	0.22*

Jordan	No	Yes HCST	–	HCST since 1987	Performers get contracts from all sorts of sponsors	Decentralized	0.34*
Syria	No	Newly established (2007)	–	No	–	Decentralized	0.12**
Bahrain	–	Higher Education Council	–	BCSR (acting as agency)	–	Trade-oriented	0.04**
Oman	–	The Research Council	–	OCIPED Invest Promo 2002	Sponsors	Trade-oriented	0.07**
Emirates	–	Institutional research and strategic planning	–	–	Sponsors	Trade-oriented	0.2
Qatar	–	–	–	Qatar Foundation	Sponsors	Trade-oriented	0.6**
Kuwait	–	Still in discussion	Yes Ministry of Higher Education and Scientific Research	KFAS funding and coordination since 1988	Sponsors	Trade-oriented	0.2
Saudi Arabia	–	KACST	Ministry of Education	KACST since 1977	–	Centralized	0.14**

Source: ESTIME final report (2007). Kuwait and Saudi Arabia: recent monographs. Data on GERD as a percentage of GDP come from ESTIME project, others from Nour (2005). Some additional information comes from the work done by S. Hanafi for ESCWA on benchmarking research systems.

historical, slow and haphazard process. Thus future attributions to specific ministries and issues such as the management of public research funds are still very much the subject of political decisions. Even if the closeness of research to productive sectors, as well as innovation, are among the main objectives of the new knowledge economy, we will still express some skepticism on the possible outcomes of a voluntary process based on changes of attributions of research from higher education to industry, as is usually proposed. In practically all Arab countries there has been rampant competition between "modernists," usually to be found in "technical ministries" (industry, telecommunications), and representatives of a political personnel that is more preoccupied with issues related to political representation and the power play that affects the state. The technicality of research makes it a weak link, and policy needs political, meaningful objects of attention. As Ignacio Avalos, a former minister of science in Venezuela, has written, the value of science is too often reduced to the value of an inauguration of some library (Antonorsi-Blanco and Avalos 1980). Universities are a "better" political object (at least a more understandable and visible one) than research, but the questions affecting universities are far away from research: the number of rooms of the student dormitories, the management of social services, the availability of cantinees are usually politically more important than the problems affecting scientific research. Moreover, there is no way to prove that improving education (that is, teaching in universities) and research will make things easier. The evidence is that research labs can feed their research activities with researchers by connecting to Masters and doctoral students. But the interaction of the university, as an organization and as a political entity, with research units is not simple in any of these countries.

Education is not only an internal political object, it is also one of the key arenas where competition between countries is focused. Higher education has been profoundly affected by global changes and the pressure placed on universities; the privatization of higher education in most countries and the connection of higher education to markets[27] go well beyond the usual willingness of the state apparatus to control student life and rein in potentially rebellious universities. Research can find its way with difficulty under this very strenuous political pressure. It is a paradox, since international rankings of universities are based mainly on outputs of research rather than teaching or other social dimensions. Finally, the predominance of Ministries of Industry, Agriculture and Telecommunications in innovation policies, as well as hospitals, is becoming a central policy-making locus for research, as they are both a place of useful research and a key employer. Moving slowly away from research to innovation has, in this way, a direct consequence of consolidating the political status of these "technical" ministries: its does entail that research be better considered!

4.3 Organization and performance of the research system

To begin with, it is necessary to mention the Arab Knowledge Report, which made a very severe assessment:

> Data related to national income of seventeen Arab countries show that Arab GDP was $1,042 billion in 2006, and yet annual gross expenditure on scientific research did not exceed two billion USD, an average of 0.2 per cent. This expenditure produced only 38 invention patents and 5,000 scientific papers, meaning that the cost of one scientific paper came to around $400,000. This estimated cost for the production of a scientific paper or patent is clearly exorbitant, and weakens the trust of society and its production sectors in Arab research programs and their researchers. In comparison, Malaysia spends on research and development 22.5 per cent of gross Arab expenditure, while Finland spends 1.75 times as much as the Arab region and registers 855 invention patents at the cost of $4.1 million each, equaling 8 per cent of the cost of one patented Arab invention.
>
> (Al Maktoum Foundation and UNDP 2009: 201)

Until now, we have tried to show that the different situation affecting Arab countries makes these generalizations less meaningful. Nonetheless, all international reports insist on the low performance of Arab countries. We would like to qualify the riddle of under-investment in research. One aspect that seems important, performance, seems unrelated to structural aspects such as policy centralization or institutional and organizational choices.

Tunisia, which has been a leading Arab country in research,[28] has a centralized science policy, as do Algeria and Egypt. These two countries have had a much lower performance, at least measured by publications. So centralization is not really a deterrent to performance. Tunisia could be our yardstick into investigating the performance of a research system as a whole, since it is the only country that has seen a spectacular growth in its research output in the last ten years. What happened before and after this growth was the implementation of a labeling policy, a somewhat unimportant administrative measure, in order to have a catalogue of research units inside the various universities and research institutions, regardless of their institutional status. The important decision was not so much the labeling, but the fact that to obtain the label the research units and laboratories needed to write a four-year project, submit a budget and explain their needs and means. This project is evaluated on a two-year basis by a national committee (CNEARS) that respected the terms of scientific excellence and research quality as its paramount criteria. As Rachid Ghrir, former director of research in the ministry explained,[29] the evaluation was totally independent from political pressure, based on evaluation committees with international standards and with foreign and national experts. The National Committee's evaluations have been very much respected, both by researchers and the administration. Although, this might not appear to be a revolution, in the context of the Arab countries it definitely changed the rules for research. The main result is to identify clearly where research is performed. Although it does not solve the riddle of under-investment, or the policy, administrative and management difficulties that are confronted by the research units, the clear identification of the performing actors of research at the "ground level" is a formidable tool. As a result, resources were more efficiently allocated and monitoring was performed both by the laboratories and the administration. This labeling and evaluation scheme has had a permanent effect on research production (see Chapter 2).

It should be mentioned that Morocco tried a somewhat similar exercise by performing a large evaluation and review process of the research system by an international expert team that brought in foreign and national experts, as well as a complete review of the research system (Kleiche and Waast 2008; Waast and Kleiche-Dray 2009). Results were not as spectacular as was the case of Tunisia; after the evaluation process took place, the government didn't sustain its policy in favor of research; for example, the "research" part inside the national accounts disappeared, the labeling of the research units in the universities took more than ten years to be completed and the whole process of reforming the research system took a very long time. Similarly, just before the Arab revolutions, Egypt went through a major overhaul of its research system after a change of minister. The change affected mainly the policy framework and permitted creation of a fairly efficient funding structure.[30] But no other country has experienced such a profound change as did Tunisia. Strangely, Tunisia stands as a paradox, being dynamic and centralized; it is a country showing both a fragile research system, but fundamentally a resilient policy and research administration (M'henni and Arvanitis 2012). Finally, maybe in a more visible manner than other Arab countries, Tunisia demonstrates the extreme difficulty of promoting technological research and innovation from within the research system. This latter aspect, the opposition between research and innovation, between promoting research and promoting technological development, is a difficult issue not only for Arab countries, but in general for research policy.

Numerous studies have tried to decipher the relation between the structure of the research system and the performance of research. None is quite conclusive, and it has to do with the way benchmarking is done: either one looks at policy concerning structural and organizational aspects, or one examines the system as an entity, where one measures inputs and outputs. The "OECD model" had strongly adopted the latter view (Henriques and Larédo 2013), and with it a linear model between inputs and outputs. In this view, one measures the performance independently from the organization. Another view would focus on the relatively complex web of institutions, which makes measurement dependent on the institutions rather than the system itself. The very central issue of funding and performance is thus difficult to examine when one focuses on the actual organization by drawing the organigram of the country. The variety of institutional arrangements does not correspond to any particular policy mix. Algeria is very centralized but demonstrates an abundance of resources, a highly complex organizational arrangement and a rather simple policy mix that does not really give research the policy space it should occupy inside the ministries in charge of research and innovation. Egypt has had a largely under-funded university system and the dominance of a Soviet-style Academy of Science inherited from the Nasserian times, where the national research center has been far less productive than one would have expected from such a large research organization (4,000 researchers). Some universities, like Ain-Shams or Alexandria University, and some hospitals, as well as some rather small but highly efficient research centers (VACSERA, Theodor Bilharz Research Institute and many others), have been performing excellent research to international standards, regardless of the rather sluggish growth of financial resources.

4.4 Foreign funding sources for research and cooperation

Relying on foreign sources as a substitute for too few national resources is a symptom of a weakness. It translates into research that has little impact. For example, a 2009 report from the United Nations Development Program complained that funding projects through foreign capital resulted in projects having a persistently weak impact (UNDP 2009: 187–188). Foreign funding can be worse: it might orient researchers to topics that are not really relevant in their own country. The debate over this opposition between relevant or international science is at the very heart of all the policy debates on research. In a sense, we could say that our own research was guided by this very fundamental question.

On the contrary, co-funding between national and international funding, or additional funding from international cooperation that accompanies a national policy, is the right way to go. In effect, all experiences of co-funding, for example between the EU and Arab countries, have been rather successful when Arab research units are not relegated to a secondary role (Pancera *et al.* 2013). Addressing nationally relevant research topics with local funds and additional international funds is not an easy task, since it includes negotiations on various policy levels. In research policy studies, this issue has only come to attention recently (Gaillard and Arvanitis 2013; Beigel and Sabea 2014; Keim *et al.* 2014), and funding is definitely the most important criteria in defining a non-hegemonic country (Losego and Arvanitis 2008). In the Arab East, Sari Hanafi (2010) has shown that the multiplication of foreign sources has been fragmenting the social sciences, and oriented the research on social issues that could be done in an academic context toward small, non-academic, policy-oriented private consultancies. Nonetheless, overall, the actual impact of external funding on research is still an open question. What is certain is that “academic” research centers in most Arab countries will actively search for external sources of funding.

As the available local funding is insufficient, research centers will tend to seek external funding. In some cases, it affects directly the research orientations of the research units. We just mentioned the case of social sciences in the Arab East (Lebanon, Palestine, Jordan, Syria, and to some degree Egypt) where research has been basically funded by foreign foundations and UN institutions. In the more technological areas, a somewhat similar process of re-orientation of research is taking place. Suffice to mention one very intriguing case, that of the technical centers in Tunisia devoted to technological research for the productive sector. As these centers continue to grow, they are seeking additional funding and, despite their valuable (possible) contribution for national development, this funding is being provided through foreign (primarily European) institutions.

In fact, the technical centers, instead of establishing closer relations with end users outside the research world, participate in research programs, such as those funded by the European Union like Framework Programs (FP6, FP7 and Horizon 2020), exactly as any university laboratory would do it. The lack of funding is not specific to the public sector, as shown by the example from Morocco, where OCP, the largest Moroccan enterprise, capable of funding its own research and development, has nevertheless turned toward foreign sources of funding, again primarily European. In this particular case, it might be a temporary situation, as can be witnessed by the announcement of a new OCP funding program oriented toward sustainable production technologies. It might also be a different motivation than the lack of funds, such as the need to connect to international research networks. Still, even companies that need research for their own products and markets are very reluctant to fund their own research in Morocco. This situation seems mainly to affect large companies in Morocco, and has been documented alongside the fact that small- and medium-sized enterprises (SMEs) have had a steadily growing introduction of new technologies and new products, as a consequence of funding applied research with their own internal capabilities.[31] Moreover, this is largely the case in all Arab countries, as attested by all the innovation surveys that have been performed in the last ten years.[32] The World Bank has ordered a study based on its Climate Assessment Surveys in the MENA region, which also confirms the importance of fast-growing SMEs (CMI 2013: 85).

The EU has shouldered much of the cost of many research projects in the Arab region through participation into European research calls. As an example, during the decade 2001–2010, in Egypt the European Commission accounted for almost half of total science and technology cooperation, mainly through the RDI Program, while the United States accounted for 17 percent, Japan 16 percent and Germany 13 percent. In Tunisia, international cooperation covers approximately 5 percent of GERD and the European funds cover approximately 40 percent of these foreign funds, 90 percent of which come from EU Framework Programs. In the case of Morocco, its specific “Advanced Status” agreed with the EC led to it being a privileged partner of the EU. Lebanon has no agreement signed with the EU, but it participates actively in all EU-sponsored projects; European projects represent around 28–30 percent of the research budget of CNRS in Lebanon (approximately €2 million).

Although the Barcelona Process, triggered by the EU in 1995 after the Barcelona Declaration, has not been a success story in economic and political terms (Moisseron 2005), it appears that scientific cooperation has been rather successful. It should be mentioned that a variety of common funding schemes have been deployed in the last few years between the EU and the Arab countries. For example, for the period 2007–2013 we can mention: a co-funding program (RDI) in Egypt (€11 million in 2007 and €20 million in 2010), a similar programmed in Tunisia (€12 million), in Jordan (€5 million), in Algeria (€38.6 million, co-funded by the EU for €21.5 million), a twinning project with57Morocco (€1.3 million), to which one should add “Erasmus mundus” scholarships and various TEMPUS projects. We estimate that the EU has spent the non-negligible amount of €300 million in the period 2007–2013.

As a result of this intense activity, the European Commission has funded international collaboration platforms supposed to facilitate dialogue between Europe and Mediterranean partner countries of the EU.[33] The EU has also created, following the Barcelona Declaration in 1994, a monitoring committee on science and technology that brings together officials from countries in Europe and the Mediterranean (that is, Arab countries' "neighbors" to the EU – Turkey and Israel) (Rossano *et al.* 2013). These institutions created a rather permanent arena for exchanges of policy experience in the region. The European Commission has funded large "projects" bringing together policy officials, as is the case of the MIRA project, followed by the Medspring project, itself being created before launching a common co-funding program between the EU, European member countries and Mediterranean partners (called ERANET MED, which was preceded by a similar project on agricultural research called ARIMNET), which is foreseen to create a large regional program, called PRIMA. All these initiatives have responded to both policy orientations of the European Commission and intense relations with the national governments of Arab countries that are partners to the EU. None of the large, well-known Arab think-tanks and international policy institutions have triggered discussions on these issues.[34] Finally, we remark that these projects are the only international forums for discussion on policy issues concerning research in Arab countries.[35]

4.5 National systems of innovation

Innovation is distinct from research, and not all innovation is research-based. This is why innovation requires special attention, separate from but related to research. Innovation policies have been developed and sustained quite firmly over the last few years by some governments, for example in Algeria, Egypt, Turkey, Morocco and Tunisia. Other countries have also promoted specific schemes and measures for innovation (Jordan, Lebanon and, to a lesser degree, Syria). Gulf countries have also established specific measures. In recent years a specific emphasis was placed by funding agencies and governments on 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 and private sectors in many forms: engineering networks; technology transfer units; fiscal measures; and funding for start-ups and venture capital. As we already mentioned, to varying degrees all the countries of the Arab region were profoundly affected by the example of the EU in its promotion of innovation and the instruments it established to measure it, such as the European Innovation Scoreboard (M'henni and Arvanitis 2012).[36]

The science parks, recently established in several Arab countries, including all of the monarchies of the Gulf, is the most emblematic type of measure toward innovation. The parks are usually part of a broader policy of promoting enterprise and partnerships in innovation, as well as research between the private and public sectors. This helps to explain the relative optimism of business executives interviewed about innovation in the Gulf for the World Bank Survey conveyed also through the Competitiveness Indicators of the World Economic Forum. These executives were particularly enthusiastic about prospects in Qatar and Saudi Arabia, which were ranked 11 and 21, respectively, out of 142 countries. Science parks have also been developed in the Maghreb, mainly in Tunisia and Morocco. For Tunisia, it has been a systematic policy to promote what it calls technopoles. In Morocco, some initial difficulties in establishing successful science parks have recently begun to give way to results. A first appraisal of science parks in Morocco and Tunisia concludes that it is too early to draw conclusive observations (Arvanitis and M'henni 2010). Nevertheless, this is an effort that undoubtedly contributed to the creation of new companies, and in some cases the creation of very successful medium to large companies. Most of these parks function as nurseries and incubators, as well as technopoles. Lebanon has what is probably one of the most successful of such initiatives, called Berytech, which has emerged as a private initiative of the School of Engineering Université Saint-Joseph (see Chapter 4). In 2009, Jordan launched El-Hassan Science Park as part of a major science project in Amman, and Egypt established its own Mubarak Science Park (which has since changed its name) (UNESCO 2010b: 256) These experiments have been extremely slow to come about and will probably need to be revamped in the future.

King Abdulaziz City for Science and Technology (KACST) is also an interesting example, since it is cumulating functions of the Saudi Arabian national science agency and its national laboratories under the scheme of a science park. The science agency function involves science and technology policy-making, data collection, funding of external research and services such as the patent office. KACST is a "science city" with three components: research, innovation and services for the public and private sectors. It has 15 research teams in different disciplines and three programs on industrial property, an incubator and innovation centers, plus a grant system "to encourage excellence and innovation." In 2011, KACST had a budget of almost US$0.5 billion, offering grants to 64 researchers and research teams. It is interesting that only 23 percent of KACST's budget is invested in basic science, while the remainder is distributed among the applied sciences (31 percent in medicine, 27 percent in engineering and 16 percent in agriculture) (KACST 2012: 105). It hosts over 2,500 employees and is in charge of the national science and technology policy, coordination of research and other government agencies, as well as performance of research, support to capacity building and technology transfers and international cooperation. The case of KACST is exceptional since it concentrates all science policy functions and performance of research in the kingdom. Additionally, Saudi Arabia is feeding its own scientific personnel and does not rely so strongly on foreign professors and researchers as the United Arab Emirates and Qatar. Nonetheless, we should remember that the accumulation of all functions in the science promotion is also a sign of a certain difficulty in generating a large and complex innovation system. The interesting aspect here is that the whole research system is concentrated in a single "science city," and what is expected is that the concentration of resources will generate a virtuous performance.

A first appraisal of innovation policies in some Arab countries has concluded that measures to promote innovation cannot be evaluated properly because of the lack of comparative standards (Arvanitis and M'henni 2010). Direct measures to promote innovation through SME-oriented programs, technoparks and incubators are easy to measure; however, even this is not done, in particular because statistics on the productive sectors are not sufficient. What is also becoming apparent after more than ten years of systematic effort in various countries is that policies have usually been short-term and success is expected to be easy and immediate; long-term efforts are not encouraged. Examples like technoparks in Casablanca, Egyptian Smart Village close to Cairo, the Berytech incubator in Beirut or the El-Ghazala technopark in Tunis are thus quite exceptional for having survived beyond the short term. It is interesting to note that Berytech owes its extraordinary longevity and success to the fact that it benefits from autonomous management based on the permanent institutional support of a university; El-Ghazala in Tunisia owes a great part of its longevity to the existence of the School of Telecommunications, even though the companies inside the technopark do not have linkages with the school as strong as might be expected. In both cases, support is not financial but rather consists of the provision of an institutional background. These two examples in what can probably be considered the two most contrary national research and innovation systems, the Lebanese and the Tunisian, show that relations between the private and the public sectors are anything but straightforward. Institutional support goes far beyond financial support and relates to the creation of an ecosystem conducive to technological development. Nonetheless, some assessments tend to doubt the efficiency of the linkage between the universities or engineering schools and departments included in the technoparks in Tunisia (Mezouaghi 2006).

What these policies show, beyond the rather centralized and very much controlled by the state character of the experiences already mentioned in the previous section, is the adoption of a network paradigm by most Arab countries. This paradigm consists of the promotion of a series of common policies that are dedicated to creating linkages mainly between research and enterprises: technology transfer units in universities and engineering schools; funding including venture capital; credit schemes favoring technological development, etc.; engineering networks; promotion of intermediate technical centers; and business associations related to innovation and technological development. Moreover, after a careful revision of policy measures in the Maghreb countries, Jordan and Egypt, experts could underline that these countries have practically experienced all forms of support for economic development oriented toward "innovation" in all its forms.[37] What seemed to lack was not imaginative policy measures, but rather sustainability and permanence of the support policies. The network paradigm certainly has the advantage of flexible arrangements. It is also strongly inspired by innovation policy concepts developed in Europe, and specifically

France. Finally, it has the additional characteristic of challenging the public research sector by asking it to establish linkages to the economy without endangering the institutional and political position of academic institutions.

We have suggested in our assessment of innovation policies that this "French style" of technology policy is very much congruent with the centralized governance of research in France, which can be found also in Maghreb countries, Egypt and Saudi Arabia. We can extend the argument to all the Arab countries: the networking has been very much preferred to other possible policy orientations. In effect, this emphasis on techno-economic networks is not the only possibility for innovation policies. Other possible orientations could have been the development of businesses with a strong public investment component, strong public–private alliances where the main partners could have been the large public corporations, preferential policies toward international investors, favoring medium-sized enterprises as "champions" in their sector, the development of strong public technical centers and the support of national preference policies related to strong industrial sectors. Many of these other options assume a strong industrial policy with choices in term of industrial sectors, something that has become a rarity, and a very strong back-up by the state. The paradox in Arab countries is that the apparently decentralized model offered by the networking paradigm has been so eagerly adopted. These policies aimed at promoting networks are relatively new and have not received a serious evaluation. This paradox of a decentralized mode of action and a rather centralized governance of all new structures can be explained by many factors, among which is the fact that network-oriented support is less demanding in terms of institutional restructuring. Moreover, we believe that what is at stake is the creation of a whole set of new actors that populate the social and economic space between firms and public authorities (Arvanitis and M'henni 2010: 233–269). We have proposed to call this ecosystem populated by units of technology transfer, start-ups, incubators, technology poles and science parks, as well as new companies that emerge around these concepts, a world of innovation (ESTIME 2007). The emergence of this world of innovation could contribute to the strengthening of industrial structures, creating a rather service-oriented sector that revolves around innovation. And, probably, that also explains the success of this way of promoting innovation.

It should be added that, within the framework of the Barcelona Process for European–Mediterranean cooperation, the EU has also suggested more innovation-related actions in the hope of creating a "Euro-Mediterranean Innovation Space" (EMIS) (Pasimeni *et al.* 2007). The idea stems from the abundant linkages between Europe and Mediterranean countries in research (Arvanitis *et al.* 2013a). But it never was embodied adequately into support of projects, as was the case for research relations. So the creation of a common "innovation space" from north, to south and eastern banks of the Mediterranean Sea is still an idea, an unaccomplished promise. Building a common *research* space is quite different from promoting an *innovation* space, the latter being rather more difficult than the former. Moreover, as we already mentioned, the monitoring of research is a difficult task, partially done through the management of projects and programs, whereas monitoring technology and innovation policy in the Arab region is still not performed.

4.6 Producing the knowledge economy

Many international organizations, bilateral donors and NGOs have sought to assist in the transformation of Arab countries' development models from low-cost to knowledge-based production: the EU, the OECD, UNESCO, UNIDO and ALECSO are only a few examples. Finally, the World Bank has actively promoted the policies in favor of a knowledge economy in the region, making assessments that are based on the knowledge assessment methodology (KAM). The KAM calculates a composite indicator called the knowledge economy index. It identifies a series of indicators (or pillars) concerning economic incentives, education, ICT and innovation. Research is only a small element among others in the World Bank framework (Reiffers and Aubert 2002), as also is the case of the Competitiveness Report of the World Economic Forum (Schwab and Sala-i-Martín 2012). It is included under the name of "innovation pillar": Arab countries rank rather low on this innovation pillar, which is based on the number of researchers, patent counts and journal articles.

As we have underlined above, on all these indicators Arab countries show low figures, without doubt. But the knowledge indexes say nothing on the dynamic that explains all these low figures. The more recent CMI/World Bank (2013) report, "Transforming Arab Economies," shows that there is a positive correlation between the country's position on the "innovation index" and their gross domestic product (GDP) per capita, except for the very rich countries (the anomaly here is rather the very high GDP per capita, something common to all resource-rich countries, rather than the low innovation performance). This has also been the result of the previous KAM index calculation (Al Maktoum Foundation and UNDP 2009: 183). In other words, despite the high GDP in oil-producing Arab countries, the ranking on the innovation and scientific research index remains very low in comparison to other Arab countries with lower incomes, or to other countries. Again, Tunisia, Jordan and Morocco perform relatively better, or rather more like the bulk of countries in the world (CMI 2013: 83). Thus, when saying, as the Arab Knowledge Report mentions, and as the CMI (2013) report repeats, that Arab countries do not show a positive correlation between GDP and innovation, it concerns only the oil-rich countries, mainly Gulf countries, and Algeria. The other countries, including the large Egyptian research system, are in a middle position, correlating rather low indicators concerning research and innovation with low GDP per capita.

Figure 1.4 reports the World Bank "innovation index" as it is computed by the KAM. The UAE ranks highest among Arab countries, followed by Qatar and then Jordan. In comparison to 1995, 12 Arab countries show a decrease in their index value for this pillar, and only five Arab countries show an increase. The Arab Knowledge Report (Al Maktoum Foundation and UNDP 2009), from where we take this figure, adds:

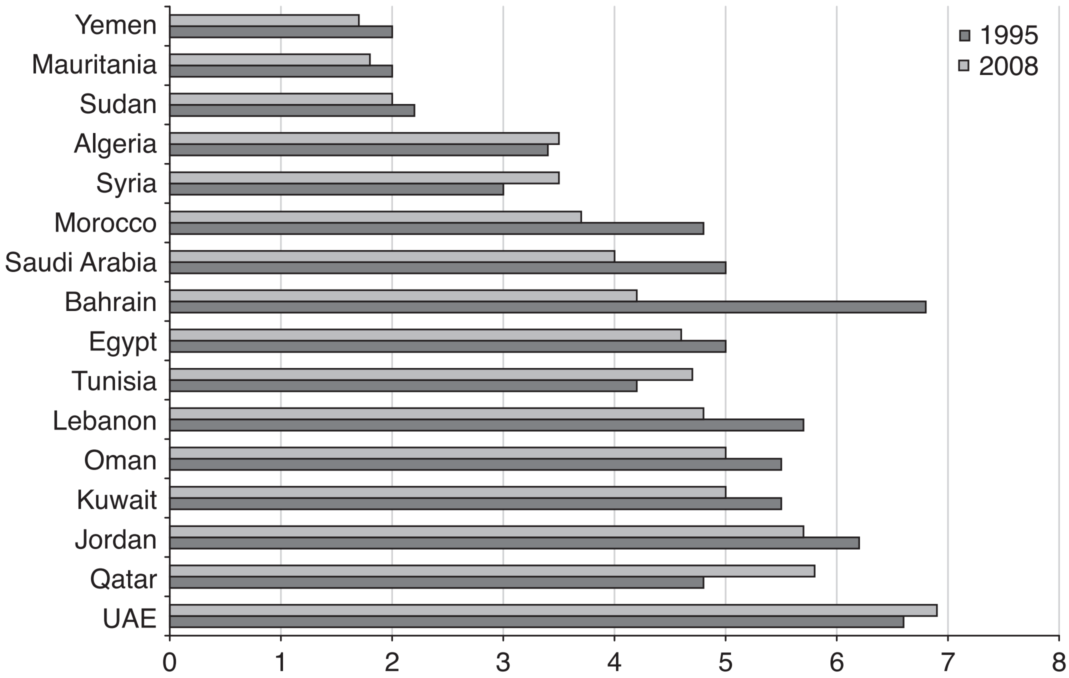

Figure 1.4 Innovation index for 17 Arab countries (World Bank knowledge economy indicators) (source: UNDP and Al Maktoum Foundation 2009; data from KAM, World Bank).

Notes
Innovation index was calculated by the World Bank based on

- researchers per 10,000 inhabitants;
- FDI per 100 inhabitants;
- trade (exports + imports) per 100 inhabitants;
- science and engineering students (percentage of total students);
- credit to private sector (percentage of domestic credit);
- domestic credit provided by banking sector (percentage of GDP);
- stocks trade turnover ratio (%);
- market capitalization of listed companies (percentage of GDP).

> It should be noted that the innovation system index value of a number of developing countries rose in 2005 in comparison to 1995. China achieved the highest increase in this value (1.06), followed by Turkey (0.71) and then Malaysia (0.63). Globally, the ranking of the Arab region decreased, whereas Southeast Asia achieved the highest increase due to the improved levels reached by India and Sri Lanka.
>
> (p. 182)

The argument of the Arab Knowledge Report consists in explaining that the Arab countries should be more actively engaged in research, and the KAM indexes serve as a warning. Before explaining what is problematic with this presentation, let us see what happened after the Global Innovation Index was devised from INSEAD, which has only existed since 2007, while the KAM was older.

In effect, we could also refer to the rather robust and more complete analysis provided by the Global Innovation Index (GII) (INSEAD *et al.* 2013). If we refer to the 2014 GII, we find even worse results: all Arab countries are under-performing in all indicators and when compared to GDP, with the exception of Jordan and UAE (INSEAD *et al.* 2014: 26).[38] We can cite the comment made by the GII Report (Figure 1.5):

> Three of the six countries of the Gulf Cooperation Council (GCC) come next [in the ranking]: the United Arab Emirates (36th), Saudi Arabia (38th), and Qatar (47th). With per capita incomes ranging from PPP$29,813.16 (Oman, 75th) to PPP$98,813.66 (Qatar), most GCC economies achieve rankings below those of their peers in GDP per capita (with the exception of the UAE, which performs on par with those of its peers), a feature common to most resource-rich economies. […] the regional (MENA and Western Asia) rankings are now more dispersed: Bahrain (62nd) comes behind Turkey (54th), Armenia (65th) and Kuwait (69th) come behind Jordan (64th), and Oman (75th) comes behind Georgia (74th). At the bottom of the regional rankings we find Lebanon (77th), Tunisia (78th), Morocco (84th), Egypt (99th), Azerbaijan (101st), Algeria (133rd), and Yemen (141st). […] Armenia, Jordan, and Georgia remain in the group of innovation learners, while Saudi Arabia, Lebanon, Azerbaijan, Yemen, Algeria, Bahrain, Oman, Kuwait, and Qatar show below-par performances compared to their income levels.
>
> (GII 2014: 35)

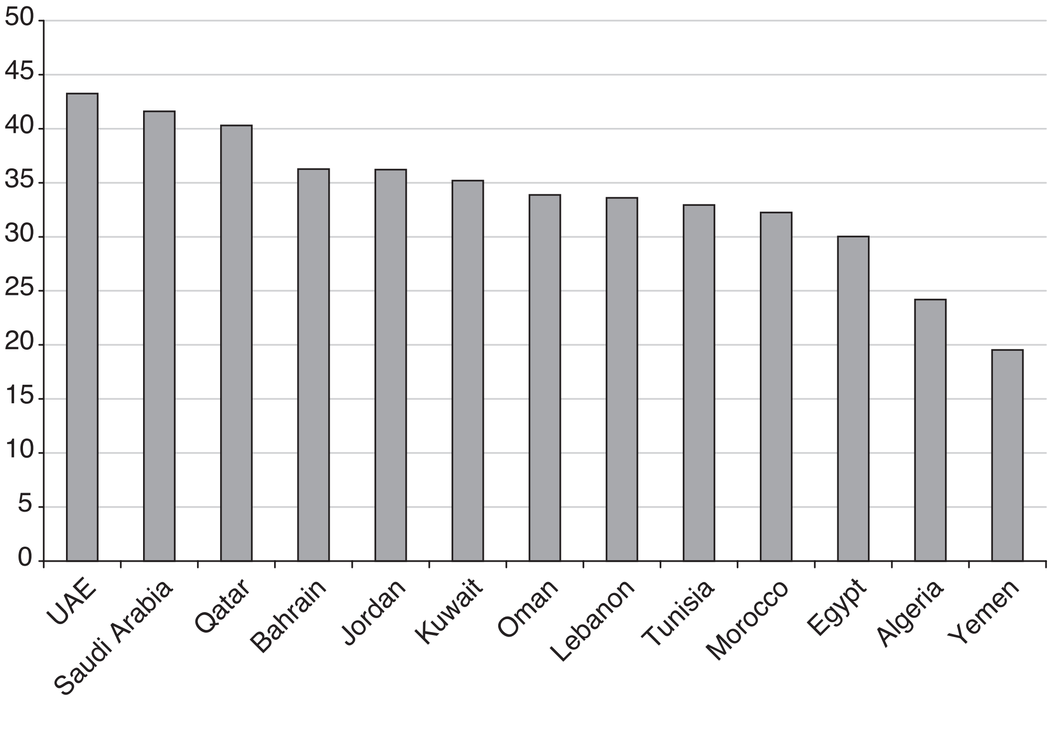

Figure 1.5 Global Innovation Index for Arab countries (source: GII 2014).

Overall, the mix of countries inside Middle East and North Africa (MENA) is so diverse that mean indicators for this "region" are meaningless. This is precisely why we proposed the above exercise in typology, identifying four quite different profiles. The GII takes great care not to be flawed methodologically, but in the end it is just a ranking: the indexes, even when balanced and carefully controlled, as is the case of the GII, cannot reflect the dynamics of the research and innovation system, nor understand the determinants that explain change. Of course, one can doubt whether what these indicators produce is not evidence on the actors inside the research and innovation system; it seems that they produce the knowledge economy itself, that is a new value system. A serious analysis of the innovation system cannot rely on the ranking of countries on a single scale, which is very much an exercise in international relations and relates to the image a government wants to give to its action. Good evidence is provided by the position of Morocco on the GII. Morocco improved its position inside the GII 2014 (ranked 84th) as compared to 2012 (ranked 88th) by creating a task force inside the Ministry of Economics that worked with the GII team in order to show that Morocco's innovation-related activities were better than predicted, and to also appear as an author of an article on human resources inside the 2014 report (INSEAD and Dutta 2012; INSEAD *et al.* 2014). The knowledge economy concerns also the knowledge of the evaluation methods used to valorize knowledge.

4.7 Toward indicators that help position actors

If one seriously wanted to monitor efforts to promote innovation, they would need to focus on actual actors of the research system: start-ups, incubators, technopoles or technoparks, industrial clusters, programs of technological upgrading, network activities between research and technical institutions with firms, such as consultancies, technical alliances between technical centers and companies. One would also need to have a general overview of actual policies – not of the "innovation system" as imagined by science and technology policy consultants, but as it actually works. In the first decade of the century, the national systems of innovation (NSIs) have been used as a unifying concept in order to assess research and innovation.[39] Strangely enough, promoters of the NSI approach have quite easily switched to the "knowledge economy" paradigm. The slippage from one to the other is paradoxical since, reading the OECD documents when it was actively promoting the NSI approach (thanks to the seminal work of Bengt-Åke Lundvall), the underlining paradigm is rather a structural argument that relates innovation to links between enterprises and productive and technical providers and clients; it is an approach that relates to industrial economics rather than the economic and financial value of knowledge. The main advantage of the NSI approach was to figure out the real actors of the system, the actual institutions that are part of the system.

On the contrary, the knowledge economy approach, by the scale it chooses to focus on, is deducing abstract behaviors from types of actors. It produces highly contestable indexes that are supposed to translate the competition among countries. The World Economic Forum, which has a clear ideological agenda in promoting free-market, reduced state, no barriers to international trade, deregulation of labor markets and freedom for businesses has titled its indicators a Competitiveness indicator. The high ranking of the small, rich and business-oriented small economies of the Gulf was then no surprise. The fact that we find similar rankings with the other methodologies (KAM or GII) proves the indicators are the same, and thus the results are similar. In fact, the overall paradigm is the same: produce a uni-dimensional measuring instrument that would oblige entering the competition by accepting the terms valorized by this unique measurement instrument.

It is not really the place here to pursue a deeper critique of these methodologies, although we can mention that they appeared once the developmentalist paradigm had been abandoned in the late 1980s. In the case of the Arab economies, they blinded more than opened the eyes of the analysts. None of the social conditions, the cognitive environment, the present political forces have ever been analyzed with the help of any of these indicators. The repeated half-truths on under-performing Arab economies was accompanying the political discourse on the "exceptionality" of the Arab political systems. These general diagnoses concerning research and innovation under the flag of the "knowledge economy" are not helping us to understand the real difficulties. Evidently, the knowledge economy credo didn't open the eyes of economists and policy-makers on what was really happening in the Arab countries – in their own countries!

If we want to go beyond the ranking approach, we should then re-engage in a structural analysis of innovation into economic activities, maybe less ambitious but more grounded than the NSI approach.[40]

5 Investment and funding in research

We have shown that the GERD (gross expenditure on research and development) occupies a middle position as a differentiating indicator in the factorial analysis presented above; it is not closely related to any particular country profile. Of course, larger countries will tend to spend more. Overall, however, funding appears to play an indirect role in defining the profile of a research system; the position of a country in the typology that we have presented above is loosely correlated to the amounts dedicated to research.

Perhaps a cautionary note is in order on the financial input data used in this book. Most rely on estimates, and the field experience of the authors suggests that the data are currently not being cross-checked. Rather, they are declarations made by national authorities, coming from very diverse sources. Most strikingly, national statistical institutions are not the ones providing data on research and innovation. Nor are the ministries that may be in charge of industry, agriculture or other services. In the specific case of telecommunications and information technologies, relevant government ministries have led specific initiatives; this is the case in practically all the Maghreb countries, as well as Egypt and Lebanon.

In nearly all of these countries, the authorities in charge of foreign investment have enjoyed regulatory powers, and as such have tried to produce specific data on the telecommunications sector. Rarely, however, have such initiatives been orchestrated in conjunction with a more general overview of research and innovation activities. Usually, basic statistics such as GERD come from estimates made by the ministry or council in charge of higher education or research. In the Arab world, there is a lack of confidence regarding these data reported by those who themselves will be judged upon it. Moreover since practically 70 percent of the costs of research and development are public expenses, and these are largely channeled through central state budgets, ministries in charge of budgets and finance may not be inclined to release statistics on research expenditures either, since they only report budgets (that is, non-executed financial provisions given through the national budgetary procedures). Finally, some sources used in international statistics, such as COMSTECH data normally used by international organizations, are strikingly different from most other sources. The methodology used for collecting and analyzing the data is not published. Finally, some discrepancies may cast serious doubt on certain figures. For example, some countries report both high GERD and low contribution to education as a whole: this is the case for both the Sudan and Qatar. Great caution should be exercised regarding the use of a single indicator.

UNESCO, through its Montreal-based Institute of Statistics, has undertaken to validate data in the Arab region, an effort which can only be encouraged; the first result of trying to collect rigorous data produced a lot of missing data for many countries, including countries where the collection of the data has been done, but it has not been validated in order to be published in the UNESCO database. The aim here would be not only to provide more transparency regarding public statistical data, but also to improve the confidence of non-public entities (in particular, private companies) in reporting on research and innovation by the Arab states.

5.1 Expenditures for research

Table 1.7 and Figure 1.6 show this absence of relation between the type of research system and the GERD as a percentage of GDP. Morocco and Tunisia are the two only countries spending more than 0.7 percent of their GDP in research and development. In the case of Tunisia, the estimate was modified by the Ministry of Higher Education and Research after the revolution of 2011.

GERD has been low in Arab countries for almost four decades and is lower than the world average at between 0.1 percent and 1.2 percent of GDP. OECD countries devote about 2.2 percent of GDP to research and development. There are signs of change, however. Egypt's GERD has remained stable at about 0.23 percent since 2007; prior to the outbreak of the revolution, the government had planned to raise it to 1.0 percent over five years, and had engaged in reform of the governance of research and innovation based on more competitive funding, more funding for research at public universities and more active government

Table 1.7 Distribution of countries according to GDP per head and GERD

Country	*GDP[f] 2010*	*GDP per capita[f] (2010)*	*Public expenditure on education as percentage of GDP (2008)*	*Public expenditure on education as percentage of total government expenditure (2008)*	*GERD (as a percentage of GDP) (2007)[a]*	*Type of research system (see Table 1.5)*
Tunisia	44.3	4,170.9	6.4	16.5	1.20[e] 0.8[e]	3
Morocco	90.8	2,882.1	5.7	25.7	0.75	1
Libya[b]	80.4	9,511.4	2.7	19.8	0.70[b]	2
Qatar	127.3	59,989.8	2.4	8.24	0.33	4
Jordan	26.4	4,199.4	4.9	20.6	0.30	3
Sudan	65.2	1,985.6	0.4	4.1	0.30	2
Egypt[b]	218.4	2,450.3	3.8	11.9	0.23[b]	1
Lebanon[c]	37.1	8,951.1	2.0	8.1	0.20	3
UAE	297.6	45,614.5	0.9	27.2	0.20	4
Oman	57.8[d]	15,996.3	4.3	22.6	0.17	2
Algeria	160.7	3,995.8	4.3	20.3	0.16	1
Syria	59.9	2,615.1	4.9	16.7	0.12	2
Kuwait	124.3	27,835.4	6.6	14.8	0.09	3
Saudi Arabia	451.3	14,744.6	5.7	19.3	0.05	1
Bahrain	22.4	19,817.3	2.9	11.7	0.04	4
Iraq	84.1	2,107.9	5.1	6.4	–	2
Mauritania	3.4	975.4	4.4	15.6	–	2
Yemen	25.3	1,060.9	5.2	16	–	2

Source: Based on Arab Knowledge Report, table 5.4, p. 193. GDP is provided by IMF estimates, billion dollars, current prices.

Notes
a World Bank (2012).
b Libya, Egypt: COMSTECH data.
c Lebanon: National Council for Scientific Research (CNRS).
d Oman: statistics for 2014.
e Tunisia: 2007 data and re-evaluated data; GERD has been re-evaluated after 2011.
f IMF estimates: World Economic Outlook database, 2010.

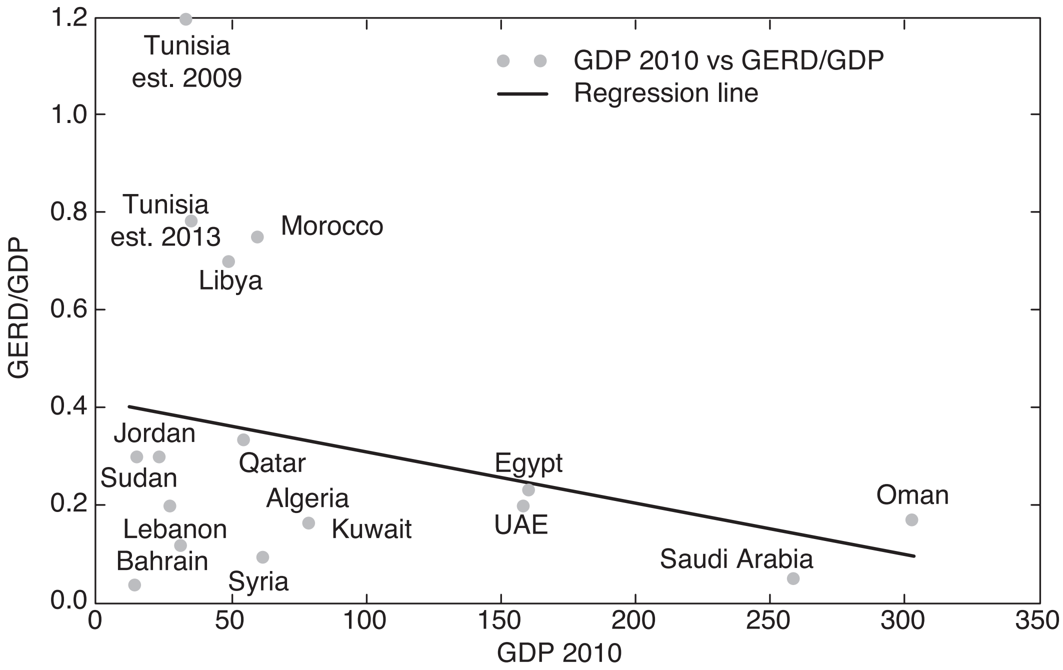

Figure 1.6 Correlation between GDP and GERD to GDP ratio (source: authors' own calculation).

structures. Although the revolution interrupted this reform process, it seems that these orientations for science and technology will be maintained. Something similar has happened in Tunisia. Prior to the revolution, Tunisia's GERD had been climbing steadily since 2000; in 2007 it was the leading Arab state for research and development intensity, at just over 1.2 percent of GDP. Even if this figure was exaggerated and re-evaluated to around 0.8 percent, it shows that Tunisia probably will maintain the advantage it has acquired over almost ten years of institutional modeling, given that, until now, the newly elected Tunisian government has not sought to challenge them (M'henni and Arvanitis 2012). Saudi Arabia, whose per capita GDP is the fifth highest in the region, adopted a national plan for science and technology in 2003 and structured KACST as its main funding institution. However, it was still ranked second-to-last in terms of research and development spending as a percentage of GDP, at 0.05 percent, ahead of Bahrain, at 0.04 percent. It really translates the fact that research is not related only to the abundance of financial resources.

There is no congruence between GERD and either GDP or GDP per capita. Indeed, investment in research is not linked to GDP in a simplistic, linear fashion. Apart from Tunisia (even after the revision of its GERD which brings it closer to 0.8 percent of GDP) and Morocco, two countries that have shown a marked tendency to support research, all Arab countries have had a rather sluggish growth of their public expenses devoted to research. Some rich countries, such as the UAE, do not invest proportionally in the development of science. This, however, relates more to the capacity to spend, which is not related to GDP so much as administrative capabilities and institutions. In fact, the UAE is among the countries with the highest growth in number of publications over the last ten years. This growth is not related to its very high GDP; much depended on the pro-research stance of the government, political system, and ambient values, in particular with regards to religion, the historical connection to Great Britain and international support.

Since authoritarianism has often forced Arab scientists to flee their countries, they end up contributing to the GDP of Western industrial states, rather than the states of the Arab region. However, the private sector and public companies in the productive sector also are partly responsible. Over the next three years (as of 2012), more than half of the companies surveyed for the World Economic Forum survey expected to increase the level of their research and development investment in the Arab region. We have no way to measure that.

Indeed, we have no valid measurement of the private sector involvement in R&D and innovation. It is usually considered that the private sector investment in R&D is very low. On a scale from 1 to 7, the estimated figures would range from 3.9 (Oman) and 3.8 (Tunisia) to a low 2.6 (Bahrain). Caution should be used with this assessment, which one can also find reproduced from the World Bank KAM, but it is in fact a figure imported from an opinion survey of business executives (more than 4,000 respondents in 2004) that is performed for the World Economic Forum.[41] The business leaders' opinion surveys reflect the opinion of individuals that are not necessarily very knowledgeable on the amounts spent in R&D. Hard data probably would provide a different image. For example, with the innovation survey in Lebanon we could make estimates concerning private investment in R&D that are not only higher than expected, but also higher than the GERD estimated until now by the Lebanese National Council for Scientific Research, which is practically entirely in public expenses.[42] Something similar happened with the figures estimated from the innovation survey in Tunisia (20 percent of business expenses in GERD) and Morocco (23 percent).[43] The efforts of the private sector in financing research is still largely unknown for the Arab countries. Our guess would be that at least between one-fifth and one-quarter of GERD is financed by businesses, but in ways and forms that make it invisible in the national statistics.

Also, the WEF result is skewed by the presence of foreign companies in the survey. Among those foreign companies, only around 40 percent plan to increase their R&D investment in the region over the next three years. Public companies that are run as private businesses but have a real monopoly are also systematically under-investing in research. Following a review of Mediterranean countries, a working group on innovation in the MIRA project concluded that very few large companies report research and development activities; among them are Sonade in Tunisia, and Sonatrach and Cevital in Algeria (Khelfaoui 2006). Morocco seemed to be in a slightly better position, but in most cases this related to highly profitable companies exploiting natural resources. Leaving oil and petroleum resources to one side, Morocco's Office Chérifien des Phosphates (OCP), one of the largest phosphate producers in the world, invests 1 percent of its sales in R&D (its sales have been estimated at around US$7 billion per year *c.*2012). A large part of that investment is not related to internal R&D but, as it is called by the upper management of OCP, to "open innovation," which consists of contracting and outsourcing research. This example comes from a company with a comparatively favorable prospect for R&D; moreover, Morocco is sharply increasing R&D investments in very strategic areas, not limited to foreign investment.

Foreign investment is usually sought in order to improve R&D. In fact, when foreign companies invest in R&D, they do little for local technological upgrading. In Tunisia, foreign-owned enterprises have a negligible impact on the economy. The analysis of the innovation survey (Gabsi *et al.* 2008) shows that foreign companies do not invest in R&D, nor do they invest in innovation locally. More generally, and contrary to popular opinion (and to the World Bank assessment, for example in its 2013 report "Transforming Arab Economies"), the same holds true for foreign direct investment in most countries. Internationalization of R&D is rather stable worldwide (at around 23 percent as shown by Larédo and his colleagues (Laurens *et al.* 2014). An exception appears to be China, where more than 400 research centers belonging to foreign companies have opened. But still, none of these appear to translate that investment into local technological innovation, except in the value chains directly related to the companies that own the R&D facilities (Mouton *et al.* 2014; Bironneau 2012). It follows that technological development and innovation in China, as elsewhere, relies heavily on public action by the government rather than foreign investment, even in very applied technologies such as biotech or nanotechnologies (Oulion and Arvanitis 2014). Studies on the R&D strategies of large global companies tend to confirm this main tendency, of a relatively independent development of R&D closely related to strategic decisions at a corporate level and local innovation. The main motives for a multinational to spend in R&D and local innovation outside its main production sites are all of a technological nature, and less market-related. There is no reason why the Arab region would be an exception.

For the most part, R&D centers in the Arab region are relatively small and focus on late-stage development, rather than basic research. Only recently have new initiatives and partnerships been established between the private and public sectors to promote research. Moreover, following some trials and tribulations, Maghreb countries have demonstrated that technology transfer units from universities to the productive sector are relatively inefficient. Most support given to research, development and innovation by national authorities is directed toward SMEs, based on the claim that in the economies of the Arab region, SMEs form not only the bulk of companies (up to 95 percent in most countries), but also provide most employment. This preference for SMEs has been the basis of "upgrading programs" from Mexico to Tunisia, and Chile to Thailand. The EU has been very keen to fund these upgrading schemes in North Africa. The results are always far below expectations and it is usually claimed that the fault lies with the programs and their management. After so many years of upgrading programs, it is time for an alternative explanation. What is needed is a diversification of economic investment: support for large investment projects in highly competitive areas (even by providing direct support to large companies, something all large economies do on a permanent basis); strong support to innovative projects in smaller entities, whatever the sector, but with regularity and in line with company growth; strong support for middle-sized (300 employees) companies with a proven record of technical success and economic strength, but insufficient investment capacity. Such policies would have a far better chance of success than the usual university-managed (and inefficient) technology transfer units or the small loans to tiny companies with no economic prospects.

From fieldwork done in many universities and technological poles or incubators, it appears that successful experiences, both entrepreneurial and innovative, are more numerous than is usually estimated. That was the conclusion reached by innovation surveys conducted in Lebanon, Morocco and Tunisia. For Lebanon, based on a 2010–2011 survey, 60.3 percent of the surveyed firms have to some extent introduced or modified products, processes and services to some degree (Arvanitis 2013).[44] Only the Egyptian survey on innovation found low levels of innovative activity and a more difficult economic environment than Maghreb countries.

A study on Jordan found a decent level of R&D spending in the private sector: 30 percent, compared to 70 percent for the public sector (this figure appears to be the highest in ESCWA countries). There is an incubator (called Oasis) with a proven record of transforming entrepreneurial ventures into viable businesses.[45] The Higher Council for Science and Technology has also pushed an initiative known as “A Professor in Every Factory” (launched in 2003), which sends academics into factories during the summer vacation. More importantly, a recent initiative, funded by a common EU–Jordan fund, is a €4 million scientific research and technological development (SRTD) program, which funds innovation-related activities in the private sector. Most of these programs have targeted SMEs. 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 centers for R&D while others have only simple units of research. They have had in most cases a quite difficult conversion to R&D (Khelfaoui 2004: 80). In the Sudan, there is the remarkable example of the Kenana Sugar Company (KSC), which used extensive innovation and created a whole internal techno-economic ecosystem. KSC introduced “green” harvesting in the region, supported by the acquisition of mechanical harvesters which allow the elimination of cane burning prior to harvesting. The waste cane leafage is converted into fodder. The same company also introduced efficient irrigation techniques, new products based on traditional sugar by-products, such as molasses and bagasses to produce animal feed and ethanol, and environment-friendly energy sources. KSC collaborates with different Sudani universities and has received their students. Recently it created a post-doc fellowship to foster this industry–academia link. Examples such as this one can be found everywhere, in particular in large companies that use natural resources, but are still rare. What is more worrisome is that, overall, larger companies are investing relatively little in R&D when one compares their income and their innovation-related expenses. The effort to invest in technology is certainly higher for medium-sized companies. A report on incentives for innovation in Morocco demonstrated this quite clearly: very efficient and up-to-date technological companies are occupying specific niches, investing massively in human resources and maintaining a very extended and strong network of providers and technical experience. All of these companies are small or medium-sized (around 300 personnel). They also tend to incorporate know-how and innovation bred internally rather than through external alliances. This is a finding that is repeated again and again in practically all innovation surveys. Thus, although investment in R&D is in absolute terms caused by large companies, often backed by public investment or public ownership (like OCP, MENAGEM, Domaines agricoles in Morocco, ONAS, CNI Sonede in Tunisia, Sonatrach or Cevital in Algeria, most telecom companies in all of these countries), based on natural resources (oil, gas, agriculture) or in infrastructural technologies (water, construction of roads, telecommunications), the most efficient in using technological investment, although lower scale, are medium-sized companies. Both the economics and the sociology of investment in innovation, research and technology is different for larger and medium-sized companies, something that is not apparent in statistics or composite indexes used to compare the achievement of one or other country. To our knowledge, the formidable resource of the Arab economies should rely on these rather smaller productive units.

In brief, when GERD is used as a measure of national scientific and technological advancement, the results for the Arab region are disappointing overall, despite the significant differences between countries, and despite numerous examples of introducing innovation rather successfully in specific companies. The annual share per Arab citizen of expenditure on scientific research does not exceed US$10, compared to the Malaysian citizen's annual share of US$33. In some small European countries such as Ireland and Finland, these figures are much higher, with annual expenditures on scientific research per capita reaching US$575 and US$1,304, respectively (UNDP 2009: 193). What we hypothesize is that the productive structures and other institutional and organizational matters count as much as political and social determinants in explaining this low investment in technologies and innovation, and the relatively limited, until now, investment in R&D. That also explains why GERD measures mainly public funding in the Arab countries, whereas in industrialized countries its is a more or less balanced distribution between public and private funding.

5.2 The debate on external funding and implications for research

> Demands addressed to research should themselves be examined critically
> (Hannoyer 1996: 401; authors' translation)

Most universities in the Arab world, where research is performed, don't have a serious budget for research. Research in the universities, and even in public research organizations, relies on external funding, both nationally and internationally. Among the foreign sources, as we said above, the EU has become a very frequent and strong partner. We found, astonishingly, the Jordanian universities' budgets are often designated to salaries and wages; the major bulk of funding comes from the EU, the biggest donor, followed by the United States and Japan, and most recently Arab countries from the Gulf. We've been told that some of these funds have political conditionality.[46] In any case, without external funding research in Jordan University or JUST in Irbid, the two largest research universities would be much reduced. The same is true for Lebanon. Universities in Lebanon, with the exception of Lebanese University, the American University of Beirut (AUB) and Université Saint-Joseph (USJ) have practically no budgets dedicated to research. AUB and USJ *c.*2012 announced an internal budget for research around US$1 million. But already in 2012 AUB received more than US$7 million from external sources of funding, and Lebanese University has notable support for research coming from French cooperation and other international funding (Arab funds, the United States, foundations and Iran). The EU has strong participation in all the research projects we have seen in Lebanon, followed mainly by the French cooperation and US funds (the latter mainly in health sciences) (see Chapter 3). What these figures show is that researchers know how to obtain funding when they are engaged in research, and the money from within their own institutions is certainly not sufficient. International funding is tied to a series of international collaborations and, thus, the research system is a worldwide system that concerns both international collaboration and funding.

Shana Cohen (2014) rings alarm bells on the impact of international aid flows and the process of global market integration in Morocco on the role of academia, not only in terms of research topic orientation but also intellectual debate on social and political subjects. She considers that a neoliberal approach to education and research may be held responsible for changes in the structure and assessment of academic work. Other researchers echo Cohen's concern, yet are less alarmist. For instance, for Jacques Gaillard (2014) there is an ongoing and growing debate, particularly in Europe, about whether the increasing reliance on competitive project funding at the expense of core funding may result in giving priority to short-term and low-risk projects to the detriment of longer-term fundamental research and/or high-risk projects as well as non-priority areas. A very similar argument has been proposed in Latin America by P. Kreimer (Kreimer and Zabala 2008), who believes, at least for the case of Argentina, that the integration of researchers in international projects is in reality a form of subordination to the orientations from hegemonic countries. There are also concerns that this trend may impact the capacity of an institution to invest in infrastructure and long-term institutional and capacity building activities.

As we have shown in other contexts, the very concept of a non-hegemonic country expresses this very unequal position in the world research system based on the idea that countries that do not have the capacity to influence the research agenda. Thus we rather prefer to talk of non-hegemonic countries instead of developing countries, for instance, because the actual system of research is not structured only around an opposition between a center and a periphery, but rather a multiplicity of cores, and a variety of peripheries; it doesn't consider exclusively developing economies but all those that progressively build a research capability and enter into research, and, most importantly, the key in understanding what is going on is not the relative positions of the countries in between, or respective to the "centers," but rather their relations to funding organizations present at the international level (Arvanitis 2011a: 636).

5.3 National funding agencies

In fact, the funding context in Arab countries is changing very quickly.[47] A number of new funding agencies have appeared or have been consolidated in recent years. Either as full-fledged public funding bodies, distributing funds by calls for projects (the Académie des Sciences Hassan II in Morocco, the Science and Technology Development Fund (STDF) in Egypt, Scientific Research Support Fund in Jordan, the National Council for Scientific Research (CNRS) Grant Research Program in Lebanon, the Qatar Foundation), or as specific funding programs inserted inside an already existing national institution (see the case of the "Fond national de la recherche scientifique et du développement technologique [FNRSDT]" in Morocco, managed by the CNRST, or the RDI fund in Egypt which is an office of the Ministry for Higher Education and Research).

The funds mobilized through the agencies represent around 1 percent of GERD, with the notable exception of Tunisia, which uses core funding rather than call for projects, although, as we have mentioned the labeling and evaluation system used in Tunisia could be considered as a national competition for research funds. Concerning these new funds that are obtained through competitive calls for projects, the situation in some of the Arab countries we know of is the following:

- The Egyptian STDF represents around 1.8 percent of GERD (considering the sharp increase of public funding for research that took place in 2011, from 0.28 percent of GDP in 2010 to 0.4 percent in 2011); before this massive increase of overall public expenditures, STDF represented around 4.5 percent of GERD.
- In Jordan, SRSF represents nearly one-fifth (18 percent) of GERD as estimated in 2008. The computation as a percentage of GDP is quite difficult to make: SRSF represents JD4 million per year for a GERD of JD22 million as reported in some documents, but that would mean 0.11 percent of GDP, not the 0.34 percent claimed by the government; if this latter figure is correct, then GERD should be close to JD63 million. In any case, the fund is now the main tool for funding research with public money.
- Lebanon mostly funds through competitive calls. Its funding represented an average of US$700,000 per year on average in the period 2007–2011; in 2013 US$1.1 million was allocated to 36 new projects. Roughly, that represents a very small amount that is equal to the annual intra-mural budget for

research in AUB or USJ. In other words, the main public funding instrument is roughly equivalent to the research budget of the two largest universities of the country (and probably also of the national Lebanese University, since it also spends approximately the same amount for research internally).

- Qatar announced a QNRF budget of US$180 million for 2014, which represents less than 1 percent of GDP[48] (far away from the more than 2 percent of GDP announced in research, but nonetheless a gigantic amount when compared to the number of personnel); QNRF is the main funding instrument in Qatar and distributes all funds for research, and the Qatar University received 45 percent of these funds.
- The Moroccan FNSRSDT represents 1.75 percent of GERD. It should be remembered that this fund is a new venture for the Moroccan government, and a very strategic one.
- The Tunisian funding for research projects is largely outside any call for projects. Core funding to labs and research units represents 16 percent of GERD, and it is not channeled through calls, except the so-called "Federative programs," which is about €1 million per year (0.40 percent of GERD). Nonetheless, as we have mentioned already, this money is distributed based on a national-level evaluation where research laboratories and teams need to submit a four-year projection of their activities. In other words, the labeling program of Tunisia can be considered a form of project-based funding. A national agency, the ANPR, has the possibility to fund research and innovation projects, and its €350,000 budget represents 0.15 percent of GERD.

As a comparison, we can remember that the French National Agency for Research (ANR) represents approximately 2 percent of GERD in France, and GERD is 2.24 percent of GDP; the NSF in the United States, with its nearly US$7 billion budget, represents 1.63 percent of the US GERD (GERD is 2.85 percent of GDP).

The figures in Table 1.8 show a profound change in policy orientation in the Arab countries, which is taking place rather rapidly.

Table 1.8 Summary of funding capability mobilized by the national funding agencies (*c.*2012)

Country	*Fund*	*Percentage GERD/actual amount*
Egypt	STDF	1.8%/US$14 million
Egypt	RDI	US$6 million
Jordan	SRSF	JD4 million
Lebanon	CNRS-GRP	US$1.1 million
Qatar	QNRF	US$180 million
Morocco	FNRSDT	1.76%/300–500 million Dh; €26–44 million)
Tunisia	Federative projects	€1 million
All Arab countries	Arab Council for the Social Sciences	Total budget of ACSS is less than US$2 million

Source: own research, project MENAFUND.

If we analyze the funding agencies, we can summarize the various functions as follows:

- Define national policy for research.
- Coordinate between different research institutions.
- Manage research centers performing research.
- Manage the status of the research activity inside higher education institutions.
- Manage programs and specific funds.
- Select and manage funding of scholarships to students and researchers.
- Support publishing of scientific journals and publications.
- Promote valorization (technology transfer) of research performed in scientific institutions.
- Evaluate the effects of policies.
- Collect statistics on research.
- Diffuse scientific culture.

As Chris Caswill (2005) insists, funding agencies provide more than funding. They provide resources for research, maximize organizational resources, facilitate "input of ideas" as Caswill calls it, quality control and interconnection between research centers. Cordero and his colleagues (2008) add "knowledge translation" as another function, as they notice an increasing interest in knowledge transfer to users and different stakeholders.[49] Funding agencies use many strategies in order to increase incentives for researchers to engage in knowledge "translation." The UK Department for International Development (DFID) examined the rules for university rankings and modified the research assessment exercise (which rates universities according to what they publish in high-level journals). Canada's International Development and Research Center (IDRC) has small grants available to move research into practice and policy. In Brazil, the State of São Paulo Research Foundation (FAPESP) funds partnerships between private enterprises and public agencies for funding basic research and developing technology based on locally conducted basic science (see Chapter 5). Many more examples could be given.

Sources of funding have become very diverse and researchers may choose the foundation that fits their research agenda. A number of national and international funds for science, technology and innovation have been set up in recent years. Among these funds are the Kuwait Foundation for the Advancement of Sciences (1978), the Qatar Foundation (1995), the Mohammed bin Rashid al-Maktoum Foundation in the United Arab Emirates (2007) and the Middle East Science Fund in Jordan (2009). Among them, only Qatar set the bar high by calling for the allocation of 2.8 percent of the general budget to support scientific research in the mid-2008. The establishment of the EU–Egypt Innovation Fund in 2008 was intended to support projects for applied research on a competitive basis, with special emphasis on innovation (Mouton and Waast 2009). Other foundations are smaller scale, such as the Arab Thought Foundation (funded by Saudi

Arabia and based in Beirut) and the Arab Science and Technology Foundation (ASTF) (UAE). Nonetheless, these Arab foundations do not seem do provide funding conducive to team work that they pledged for the research, but are setting up spectacular events such as prizes for best book or best woman researcher, etc.

5.4 Some hypotheses on the increase of funding in Arab countries

The creation of the funding agencies was closely linked to changes in the institutional landscape that concerned the policy-making structure rather than the performing institutions (universities and public research organizations). Reasons for change are always multiple, depend on the political situation, and can be read as the result of different forces that translate into a (temporary) political "equilibrium," in particular when the policy-making agencies are concerned. We only mention some of these concerning Egypt, Morocco and Tunisia.

In Egypt, these changes happened some years before the popular revolution that brought the end of the Mubarak regime. It was related to a change in the person acting as the minister of higher education and research, who proposed the modification to the policy-making structure. By dismantling the old Academy of Science, which was transformed into an advisory board, and re-integrating policy orientation functions inside the ministry, the new ministry regrouped all policy functions under its authority. It also abandoned the old soviet structure that had modeled the national research center and the Academy. In the process, policy coordination functions became clearly apparent as the most important ones. The change was very closely linked to the EU, which offered strong financial support, around 2007, and became the financial basis of the RDI program. Moreover, the EU appeared as a larger framework in which national research could be both embedded and obtain additional funding. The compatibility between the EU mode of action (funding through specific calls) allowed progressive legitimization of the funding by projects within the Egyptian scientific community.

In Morocco, an overall re-engineering of the policy-making functions was expected for many years – in fact, after the creation of the Académie des Sciences Hassan II (2006) and the non-replacement of the director for research who occupied the function of director of CNRST (2008). In the meantime, the ministry drafted various diagnoses of the state of research and governance of the research system (since 2005), and headed various bilateral projects with the EU, and was subject to a whole re-engineering process. Again, the government used the advice provided by the EU, mainly through bilateral projects (M2ERA and Twinning project). These provided inputs on the possible transformations of the institutional set-up. A plan of action for 2013–2016 was the product of this intense policy-making exercise.

Both Egypt and Morocco had a multipolar research system, under an apparently very hierarchical system, and in both cases it became apparent that reinforcing research passed through a consolidated coordination. The agency model appears thus as an adequate tool for this coordination through funding.

In Tunisia, changes were less the result of the revolution than a process of accommodating competing political forces. The whole political process made apparent strong oppositions that were embodied in specific offices and ministries with strongly diverging views on how to implement policy. The main changes in the overall policy-making structure was, most probably, the creation of the national evaluation committee (CNEARS) that labeled laboratories and research teams in order for them to receive public research funds. The second orientation that played an important role was the creation of the technopoles. Although much less was done than planned, technopoles posed a question of the connection of society to national needs. Also, a notable difference was that, contrary to Egypt and Morocco, Tunisia, under the Ben Ali regime, was very cautious concerning EU funds. International cooperation was closely monitored by each minister and, in some cases, collaborative projects could not be implemented because of a veto issued by the office of the minister. When the regime fell, although the whole policy infrastructure was very loosely modified, changes happened only concerning this opening to the EU. It became suddenly an open battlefield on who by and how the bilateral program with the EU should be monitored, opposing quite openly the Ministry of Industry and the ministry in charge of research. The last years of the Ben Ali regime had been those of a closing down of the system, mainly for reasons of political control. Extreme political tension has nearly paralyzed the research system, which probably survived this deep crisis after the revolution because the labeling structure (the national evaluation committee and the subsequent designation of working research units) that identifies clearly the public performing actors (units and laboratories) has been functional all along. It is thus not entirely strange that Tunisia has been less willing to adopt funding by projects: in fact, its system of approving core budgets for laboratories is a sort of national competition. Moreover, the main difficulty faced by Tunisia was not so much coordination, as in the case of Egypt and Morocco. The agency that could efficiently manage the calls, the ANPR, is still not in charge of the funds, including when this was supposed to be the case. If funding by projects is to be implemented it will probably be the result of pressure not from within the policy-making structure, but from below – that, is from the scientists themselves.

It should also be noted that changes of the institutional framework for policy-making have been affected by the Euro-Mediterranean policy driven for some years by common policy activities, mainly through the Monitoring Committee for Science and Technology and programs funded by the EU[50] (see Section 4.4). The policy objectives of the EU have affected the research institutions (policy-making bodies and performing institutions) on research orientations, and on the management aspects of research projects. It has not been a uniform influence, although the EU has had a one-and-for-all unique "neighboring" policy. There is some debate on the difficult question about the actual influence of the EU and its impact in the Arab countries. We have already mentioned the relatively high support in financial terms channeled through various programs and the participation of Arab researchers into the EU calls for projects (open to all since the 6th

Framework Program). Although the so-called, Barcelona Process triggered by the EU in 1995 has not been a success story in economical and political terms (Moisseron 2005), it appears that scientific cooperation has been rather successful. This is also a paradox since science and technology were not explicitly mentioned in the initial Barcelona Declaration. The influence of the EU on Arab countries has in fact been very different between countries. This effect was quite straightforward in Egypt, with the creation of RDI inside the Ministry of Research, an office that managed the €17 million fund in Egypt. The Scientific and Technological Development Fund (STDF) in Egypt was launched a little time after the RDI program and was certainly influenced by the success of the RDI program, along with bilateral collaborations (e.g., Germany and France). Nonetheless, the example of RDI is quite unique. Research funding agencies in most other countries have been created independently of the EU and under their own terms. The cooperation with the EU, which also increased considerably in most Maghreb countries, has served as a strong incentive for more research and for the structuring of the funding structures. For example, Morocco underwent a long process of reform and finally decided to launch calls under a new national fund, FNRSDT. The launch of this program was driven by previous learning acquired through previous pilot programs (PARS, PROTARS). These previous programs provided very important proportions of laboratory budgets (up to 60 percent in certain cases), and the experience was considered beneficial to those participating in these experiences.

It is thus debatable how much international collaborations and cooperation with the EU influences directly the policy choices or "drive" policy changes. The adoption in Egypt and Jordan of project funding schemes in cooperation with the EU was not entirely related to European cooperation. Something similar happened in Morocco and Tunisia. The 2007 reform of the policy framework in Egypt was embedded in a larger reform of the science policy in the last and short-lived Mubarak government. If these changes were asked for by all the scientific community and took place before 2011, it is also because a larger need for change was felt even inside the policy driven by the authoritarian regimes. The EU relation that we depicted above certainly acted as an incentive, but we cannot affirm that it was the main driver of these changes. Geographic proximity and historical ties account for a lot in the explanation for the rather intense exchanges between the two banks of the Mediterranean Sea.

In brief, the main hypotheses that can explain both the institutional changes as well as the increase in funding in many Arab countries do not seem to us less related to the external influences, or some willingness to modernize the technocratic structure of the state. It is rather the response to real, permanent and politically strong pressure that come from the ground: unemployment, the need for new business opportunities, the changing economic conditions, as well as the increasing scholarly population that seeks, before emigrating, to get a job locally. It is this same pressure that explains the relatively abundant creation of new businesses based on technology and innovation, the extension of research bilateral agreements between rich European countries and non-hegemonic Arab countries. In the social sciences, after the Arab revolutions, but also as a product of the increase in the academic population, the governments needed to respond to the demands for more funding and more working academic space.

6 Conclusion: toward a more diversified research system

The World Bank has indeed designed a Knowledge Economy Index (KEI) and a set of policy recommendations for the future based on the liberalization of the economy: more science and technology, more innovation, more entrepreneurship, more privatization, more flexible markets and less state control. This model has ranked Arab countries in such a way as to champion Gulf states as models of Arab knowledge economies (Figure 1.7). When comparing the KEI and the GII, one finds differences that are mainly due to a stronger emphasis on economic

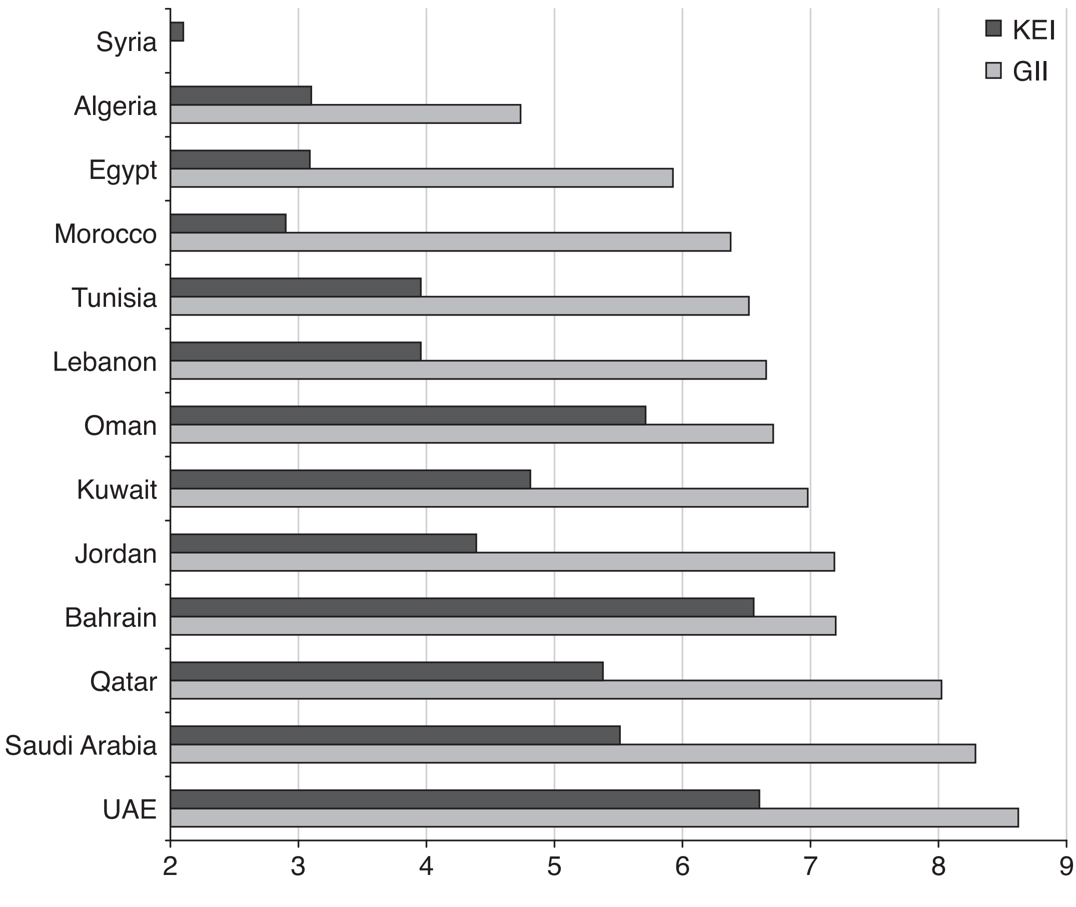

Figure 1.7 Knowledge economy in the Arab region: comparison of knowledge economy index (KEI, World Bank) and Global Innovation Index (GII) 2012 (source: KEI, World Bank, reproduced in "Transforming Arab Economies," p. 28. For GII, same as Figure 1.5).

Notes

Ranking based on the calulated value of the GII and KEI, normalized on a sale from 1 to 10. Minimum KEI is Syria at 1.9 and maximum is UAE at 6.6. For GII, minimum is Algeria at 4.7 and maximum is UAE at 8.6. Syria is not calculated in GII. GII is more consistent with the analysis presented above.

and financial conditions in the Gulf countries. The UAE, Bahrain and Oman lead in the KEI index, whereas the UAE, Saudi Arabia and Qatar lead in the GII. Interestingly, the countries that have a longer research tradition and permanent effort on the part of the government, such as Lebanon and Tunisia, do not fare well in the KEI but rather better in the GII (one should remember that the ranking is worldwide). GII also gives higher grades than KEI to countries that we have proven to be rather larger research systems, with the exception of Algeria, which gets lower marks on both indexes. The detail of the comparison is not really telling us about more than this quite unequal treatment between oil-rich countries and middle-income economies. The normative behind this glorification of Gulf countries looks very much as an overestimation of rich and small countries versus middle-income countries. Is this really what the knowledge economy should boil down to? Does this reflect the diversity we tried to analyze in the above pages?

We advocate for a more diversified model, which would take into account the various types of sciences and the different roles played by the state, depending on the nature of the economy and societal issues at stakes.

The multiplicity of research centers and actors is growing. This is true in all Arab countries; innovation and research policies insist on coordination rather than production and funding, and coordination of various entities, rather than production of knowledge in public mission-oriented research organizations, becomes the new principal orientation of policy. Nothing can tell us today if this is beneficial or not. Managing more complex institutional models is probably more complicated for a state that wants to control everything. Arab countries do share a common feature: their governments are afraid to give up control over the institutions. Moreover, coordinating various research performing structures in different areas and under different organizational modalities will be less easy than the older policies geared toward "capacity building." It supposes, in a given country, the government will agree to take into account a rather wider span of actors than it used to do, participate in defining the agenda outside the sole objectives and priorities of its own agencies and needs, accept being challenged on its own ground and on its sovereign decisions by agencies that are richer, stronger and with different objectives than its own. All of these new policies contradict the usual command-and-control habits of policy-makers in Arab countries.

Innovation policy is probably one among many other areas where these governance issues will be abundant. The diversity of firms, the need for specialized expertise, the necessity to seek funding, the fact that Academia will also claim for better management rules, openness and autonomy, as much as for more funding will put additional pressure on the research and innovation governance. Moreover, most of the research and innovation activities need to be performed in close connection between national and foreign researchers, investors and academics.

We don't believe that imposing a uniform knowledge economy view will unlock creativity and resources. On the contrary, everything out of the last ten to five years, including the revolutions, tells us another story, where multiple actors will fight over rare resources by creating multiple decentralized research units, either in companies, or in private as well as public universities, in technical centers and consultancy companies. It is rather a chance for the future, although it will raise new issues concerning the labelization of research, the certification of quality, the coordination of different entities and the ability to manage a rather large and decentralized research structure.

Notes

1 See UNESCO Institute of Statistics (Montréal): www.uis.unesco.org.
2 See OECD Directorate of Science, Technology and Innovation: www.oecd.org/sti.
3 COMSTECH is a Ministerial Standing Committee on Scientific and Technological Cooperation established by the Third Summit of the Organization of Islamic Countries (OIC): www.comstech.org.
4 There were strong debates triggered by the UNDP report on knowledge in the Arab region (UNDP 2005). The report was followed by a much less polemic version, co-funded by the Al-Maktoum Foundation, known as the Arab Knowledge Report (Al Maktoum Foundation and UNDP 2009).
5 www.globelics.org.
6 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). See the book of the MIRA project, which mentions in some detail the institutional framework of research and cooperation in the Euro-Med area (Morini *et al.* 2013).
7 Published as an article.
8 For Southeast Asia, see the special issue of the *Journal of Science, Technology and Society*, March 2006 Vol. 11, No. 1. In particular, the introductory article by Intarakumnerd and Vang on China; see *China Innovation Inc*. (Bironneau 2012).
9 Again, we maybe appear over pessimistic in this regard, but the relatively scarce research activity in the history of science is a case in point. Although all governments and official meetings talk about the glorious past of Arab science, it is very rare to find good reliable research on these topics. History of science has, unfortunately, been mobilized by nationalistic discourse. See the case of the creation of a national research center for history of science in Syria.
10 The socio-economic literature is abundant on these matters. A recent case of reflection can be found in the study published by Leresche *et al.* (2009), which examines the opinions on science in the European Union based on a very large opinion poll.
11 www.globalinnovationindex.org.
12 www.e-marefa.net.
13 This database contains 1,015 academic and statistical journals issued by various bodies (universities, research centers, public statistical departments, central banks, scientific associations, regional organizations) in the Arab world in three languages: Arabic, English and French. E-Marefa database provides 100,000 articles and statistical reports, 11,000 theses and dissertations (Masters and PhD) and 7,500 book reviews issued in the Arab world. This database involves over 275 universities, research centers, statistical apparatus and regional organizations in the Arab world in 19 countries. These bodies supply their journals and publications to Marefa database on a regular and continuous basis. Other than E-Marefa, there are also two databases: one for all science, called al Manhal (www.almanhal.com) but its coverage is much

less important than E-Marefa. The second concerns only literature on education (produced in the Arab world or about it), called Shamaa (*šabakat al-maʿlūmāt al-ʿarabiyya at-tarbawiyya*, i.e., Arab Educational Information Network). Currently about 20,000 studies are documented in Shamaa, 5,000 with their full text.

14 Good examples are the tools proposed by Loet Leydesdorff or the IFRIS Cortext platform (www.ifris.org). The bibliometric work once based on exploiting online data, went next to desktop research and now returns to online collaborative research. For Chapter 8 we have used the network analysis tools of Cortext.

15 We can mention the work collected in the books of the Alfonso network, coordinated by Roland Waast, to which both authors of this book contributed (El-Kenz and Waast 2013; Gaillard *et al.* 1997a).

16 A good overview of issues on this topic can be found in the European Science Foundation report (ESF 2012). Many research organizations have issued reports in the recent years on this topic. Science Europe, a lobbying organization created by mostly European agencies and public research organizations is elaborating a general recommendation on the issue.

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

18 Science Europe, a lobbying body that groups most European agencies and public research organizations, is developing an analysis of the measurement of the impact of research (www.scienceeurope.org).

19 See our take on the subject in a small opinion article: “Ranking Arab Universities: A Farce” available at: http://tadweenpublishing.com/blogs/news/18584321-ranking-arab-universities-a-farce.

20 Even those are rarely performed. An example of such a scoreboard has been produced by Waast and Rossi (2009) and published only on the MIRA website (www.miraproject.eu). These authors have published an article that shows how to articulate the macro bibliometric indicators and more detailed micro indicators in the case of Arab countries (Waast and Rossi 2010). All documents concerning this issue in the Mediterranean are published on the MIRA website under the topic: “WP2 – Observatory of the EU-MPC Cooperation in S&T Public Library.”

21 These changes in the policy framework have been analyzed in the frame of Euro-Med cooperation (Arvanitis *et al.* 2013a). They have been the subject of research in the Arab world headed by the authors of this book (Arvanitis *et al.* 2014).

22 No Varimax rotation was made.

23 Anne-Marie Moulin has written many interesting analyses of these research fields that were linked to health. She has proposed a very stimulating synthesis (Moulin 2015).

24 This center, along with all the 15 international agricultural research centers, are coordinated by the Consultative Group on International Agricultural Research, based in Washington (www.cgiar.org).

25 A survey of Euro-Mediterranean observatories has been undertaken by the Medspring project. Survey analysis by R. Artweh, A. Riss, S. Sanna and R. Arvanitis, updated June 2014 (http://medspring.eu). This is ongoing research with an objective to

produce a complete analysis by the end of 2016, and concerns mainly, but not exclusively, environmental observatories.

26 Figures have changed since this assessment, but more or less the numbers are close. For a complete overview see ESTIME background report on Tunisia (M'henni 2007; www.estime.ird.fr/article240.html).

27 See the special issue on higher education and elites in the *Cahiers de la Recherche sur l'Education et les Savoirs, N° 14 (2015)*, by E. Gérard and Anne-Catherine Wagner.

28 Even if it has been probably publicized as far better than it really is, because of preference for science and technology since long ago, that was conformed under the authoritarian regime of Ben Ali, Tunisia still has a very impressive record for research in academic environments.

29 Rachid Ghrir, "Evaluation de la recherche en Tunisie," Atelier ESTIME, Alger, July 2006. Recently, Dr. Ghrir explained the ins and outs of this policy in a Forum for Research Funders in the Arab Countries, Cairo, December 2015. The first description of the process has been detailed in the ESTIME national background report for Tunisia (M'henni 2007).

30 A study of the major changes in the policy framework in Egypt has been written by Kyriaki Papageorgiou, as part of the Scoping study on "Research Granting Councils and Funds in the Middle East and North Africa (MENA)" directed by S. Hanafi and R. Arvanitis (2012–2014), funded by the International Development Research Center (Canada).

31 Gaillard, J. and Afifi, A. I. (2013). Jumelage institutionnel (MA09/ENP-AP/OT14) "Appui au Système national de la recherche (SNR) au Maroc pour une intégration à l'Espace européen de la recherche (EER)" and report by Arvantis *et al.* (2012) on incentives for research. See also the background reports for ESTIME by Kamal Mellakh (2007) and Jamal Assad (2007).

32 For a review of these documents and the innovation surveys, see Arvanitis and M'henni (2010). In Tunisia, see the third part of the report directed by Hatem M'henni (2007) as well as the report by Abderraouf Hsaini (2007). For Morocco, see above.

33 Projects MIRA and MEDSPRING, and funding programs such as ARIMNET, ERANET MED and PRIMA (in process at the time of writing).

34 The Arab Thought Foundation and the Al-Maktoum Foundation have issued many reports on the state of science and technology, none tackling this issue.

35 Let us remember that both Turkey and Israel, which have buoyant research and innovation, have been less interested in these exchanges since both countries are associated countries to the EU, and thus contribute and participate into the European Framework Programs as full members.

36 The Arab League is still promoting very actively the making of an Arab innovation scoreboard, in partnership with the European Investment Bank.

37 Apart from the already mentioned article by Arvanitis and M'henni (2010), a series of reports inside Euro-Mediterranean projects MIRA and MEDSPRING have focused on these innovation promotion policies. Most unpublished material has been used repeatedly by government officials when designing new policy measures.

38 The team calculates efficient innovation by comparing input/output composite indicators. See details in the GII (INSEAD *et al.* 2014: 3–27).

39 Good examples of this type of analysis in the Arab world has been the work of A. Djeflat – see his latest book (Andersson and Djeflat 2013).

40 This claim, to our knowledge, is rather rare; but see the thesis of Roberto Lopez-Martinez (2006).

41 As cited by the Arab Knowledge Report (Al Maktoum Foundation and UNDP 2009: 193). The report mentions: "The private sector makes a relatively active contribution to funding research in Oman, Tunisia, Qatar, and Saudi Arabia, with an indicator ranging from 3.5 to 3.9 (with 1 being the lowest and 7 the highest)." This figure

(private sector spending on R&D) is an estimate, apparently based on the Executive Opinion Survey performed by the World Economic Forum. See World Economic Forum 2002/2003 Report, page 40. The methodology and survey results are not published. Two years later, the WEF report's executive summary mentions (p. xviii): "Survey data for these countries [United Arab Emirates, Saudi Arabia, Bahrain, Egypt, Gambia, Uganda, Zambia, Nigeria, Mali, Chad, Angola] have high within-country variance. Until the reliability of survey responses improves, with future educational efforts and improved sampling in these countries, their rankings should be interpreted with caution."

42 Data still not published at the time of writing; we have respected the embargo on the report, which will be published later in 2015.

43 In 1996, estimated business expenses in R&D were $US22.6 million. It is a very unreliable data published by ESCWA (1998: 19). R&D expenditures for 1996 (22.6 million) and 1992 (3.7 million).

44 Overall in the sample and for the years 2010 and 2011, 45.2 percent of firms introduced new or improved products, 29.5 percent introduced new or improved services and 43.7 percent introduced new or improved manufacturing processes (Arvanitis 2013). Similar figures appear in all innovation surveys, with the notable exception of Egypt, which indicates much lower figures.

45 SWOT analysis of Jordan Science System, ESCWA (unpublished report).

46 In Jordan, some researchers we interviewed were reluctant to participate in European or American research projects due to Israeli researchers' participation. They stated that they believe that such projects aimed at the integration of Israel in the region.

47 A lot of the information on funding comes from our research with Canada IDRC (Arvanitis *et al.* 2014).

48 We have no estimates for GERD for Qatar and figures do not fit quite well; another source of information mentions that Qatar National University funded research for US$220 million, which looks to be an extraordinary amount (this is close to the budget of a medium-sized institute with fewer than 900 researchers and fewer than 2,000 personnel in France, for example). Moreover QU announces it receives US$266 million from QNRF – an average of 40 million per year.

49 They surveyed research funding organizations in the health sector in six countries in Latin America, Asia and Africa to identify the extent to which they promote "knowledge translation."

50 Most information on these Euro-Mediterranean policy framework changes as well as about the MoCo are publish in a book by Morini *et al.* (2013).