Science, Technology and Innovation Measurements in the Maghreb Union (AMU) and the Impact of Indicators: The Institutional Dimension

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ABSTRACT
The role of science, technology and Innovation (STI) as an engine of development has been globally recognized. This needs the formulation and regular reviews of policies using good and viable indicators. However, in most African countries, policies suffer from the negligible importance of indicators in the eyes of policymakers. The five Maghreb countries (Algeria, Libya, Tunisia, Morocco and Mauritania) have been putting significant efforts to improve publications and patents on the ground that they best translate the effectiveness of STI policies. The findings show that real progress has been made in recent years on these indicators in the region following the policies adopted. Looking more in depth at the Algerian situation, the results indicate that STI indicators have been able to transform policy-making through learning, and international cooperation this progress has been slowed down by institutional constraints and limited inclusiveness. Our contribution is to highlight the importance of having a proper institution in STI indicators construction and usage in African countries. The methodology used secondary data and an in-depth case analysis through the observant participant approach.

Keywords: STI indicators, Maghreb countries, Patents and publication, Institutional constraints, Transformation and learning capacity.

INTRODUCTION
Science and technology and Innovation (STI) as an engine of development need the formulation and regular reviews of policies using good and viable indicators. However, in most African countries, policies are not based on scientific facts partly due to the negligible importance of indicators in the eyes of policymakers. The five North African countries (Algeria, Libya, Mauritanian Morocco and Tunisia, in alphabetical order) which constitute the Arab Maghreb Union (AMU) have made substantial progress on two indicators: Publications and patents through proactive STI policies. We examine the link between these policies and the two indicators in all five countries in a first part. In the second part we will examine in depth the use of indicators in the auditing of the National Innovation System of Algeria and examine more specifically the institutional issues raised.

BACKGROUND
One common observation is that Science, Technology, and Innovation (STI) policies often do not stimulate innovation which could lead to growth, better living, and employment. While there is a significant increase in several STI indicators, only few African countries seem to be keeping pace. To address some of these weaknesses, Africa has been moving fast since the birth of the NEPAD (New Program for African Development) in 2001 through several initiatives taken at continental level. Thus, the ASTII (African Science and Technology and Innovation Indicators) initiated by AU-NEPAD[1] programme in 2005 is part of Africa’s Science and Technology Consolidated Plan of Action (CPA). It aimed at building capacity to produce common internationally comparable indicators[2] and to overcome this weak dimension of STI policies Siyanbola.[3] There are other weaknesses: firstly, indicators play, often, a negligible role in the eyes of policymakers lumbered with more basic development problems. Secondly, in many African countries, there is a gap between STI policy and development priorities often the result of the lack of coordination. Thirdly, the statistical instruments used are far below the current standards that accompany a proper STI indicators policy. The main official statistical bodies are usually not accustomed to produce STI oriented statistics due to lack of demand from policymakers Jerve.[4] To address these problems, the AU (African Union) Agenda 2063 launched in 2013 emphasized the role of STI to realize African unity and attain overall integrated and sustainable development. It was followed a year later by the 10-year Science, Technology and Innovation Strategy for Africa.

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(STISA–2024) aligned to it. This translated, evidently into even more pressing needs for higher standards indicators, internationally comparable, and easily accessible by policymakers.

Haut du formulaire

The five Maghreb countries have spent more than thirty years trying to have proper STI policies. They have been building and implementing various programmes, often with the support of international organisations to build their national research and innovation systems. Everyone admits that the region has made notable progress towards STI strategy formulation and implementation Bizri, Radwan. New laws and institutions, new S&T agencies, new governing bodies have been created together with substantial research funding. These policies seem to have given substantial results on certain indicators, without, however translating into satisfactory levels of innovation as shown by Radwan. The Global Innovation Index (GII/2020) shows unfavorable rankings (121st for Algeria, 78th for Tunisia and 85th, for Morocco) when benchmarked with comparators from advanced and emerging countries. They are still lumbered with problems of STI indicators which remain unsustainable and suffer inadequate information originating sometimes from official government bodies. Consequently, we are confronted with several key issues and research questions: What role do STI indicators play in policymaking in Maghreb countries what institutional support do they have and how inclusive are they? What is the role of international networks in building capacity among decision- making bodies? Our main hypothesis is that capacity building in using indicators goes beyond the simple technical problem but extend to the institutional and political spheres.

OBJECTIVES AND SCOPE OF THE STUDY

To address these questions, this paper seeks to bringing to light the critical role of STI indicators for enhanced evidence-based STI policy-making and sustainable development in the Maghreb.

We pursue two objectives: first to look at the data of the five countries on the two major output indicators: publications and patents on the ground that they best translate the effectiveness of STI policy. The second objective, which is the main one, is to examine in depth the role of STI indicator capacity in transforming STI policies in the Algerian experience and the weight of institutions.

LITERATURE REVIEW

The role of science and technology (S&T) as an engine of development has been globally recognized in several contribution Juma Muchie Djeflat. What gives a nation competitive edge is the speed it can identify, utilize, and diffuse new knowledge as shown by Prusak and feed it into explicit strategies and policies to effectively drive innovation and development. This needs the formulation and regular reviews of STI policies in driving sustainable development OECD, Siyanbola et al. and a good mastery of indicators. STI indicators setting constitutes, however, a major weakness of African countries though the situation differs from one region to the other and from one country to the other as shown by Gaillard, Gaut and Siyanbola et al. Some important imbalances exist on the continent according to M’Henni. Only few countries, namely South Africa from sub Saharan Africa and Egypt from North Africa are keeping the pace on certain indicators such as publications and patents as shown by Gaillard et al. Djeflat and Radwan. The marked lack of demand for STI indicators to formulate regular review of STI policies from policymakers and practitioners has been highlighted in the literature Olaopa et al. and Siyanbola et al. Maghreb countries and in particular the three most important ones (Algeria, Tunisia and Morocco) are locked in the middle income trap unable to move to high STI driven growth and to join the club of the emerging economies Arezki et al. This is the result of not properly harnessing STI strategies, and adequate implementation and monitoring using indicators. However, their width and depth depend also on the stage of development of STI. Manyuchi and Mugabe found, that South Africa, for example has been making efforts to use innovation surveys while Malawi, has no institutional mechanism dedicated to produce STI indicators and there is no evidence that policy makers are being informed. Dialogue remains another important dimension in setting indicators Dutrenit et al.

Maghreb countries are still in the process of setting proper STI strategies. Using Arber et al. typology for Latin America they fall within the C Group (countries with incipient R&D systems). In this respect, none of them produces regular R&D surveys but only occasional compendia of STI statistics.

Setting indicators in African countries is not an easy task in view of the size of the informal sector whose dynamism is legendary in the sphere of “below the radar” innovation, often difficult to harness as mentioned by Kaplynski. Yet, the informal sector represents quite a substantial share of income and employment: 49.46% of the total non-agricultural employment in Algeria for example as shown by Bensaoula. Milberg and Vonortas have put indicators into a historical perspective by producing four generations of indicators: the first one relates mostly to input indicators in the sixties, the second one to output indicators in the seventies and eighties, the third one to innovation indicators in the nineties and the fourth generation to process indicators in the years 2000.
The three main Maghreb countries can be classed in stage two i.e.: Second generation output indicators moving fast towards the third-generation innovation indicators. This does not apply to Mauritania and Libya (Table 1).

Based on these elements and the specific situation of Maghreb countries, we will try to put forward our conceptual framework.

**CONCEPTUAL FRAMEWORK**

Maghreb countries have been making a substantial effort to improve their STI policy both through a constant effort of reforms and through building several research institutions, long before any kind of interest in innovation. It is only in the nineties that this effort on research appeared to be too narrow in the eyes of policy makers and needed to be extended to other dimension of STI, namely Research and Development (R&D) and innovation. Consequently, they started developing strategies and policies to harness these two components simultaneously and putting the necessary effort in terms of resources and institutional reforms. In Algeria, for example, the 1998 law on STI is considered a major turning point in this respect. In Morocco, the 2000 law triggered several reforms in the national system of educational research aiming at promoting innovation. In Tunisia, an orientation law relating to scientific research and technological development was promulgated in 1996 and amended in 2000. Analyzing the situation of STI in the region, Bizri highlighted this turning where the reforms following the laws in Algeria, Morocco and Tunisia were all geared towards more STI and innovation driven development. The two other countries of the Maghreb have been lagging because of conflict (Libya) or lack of resources (Mauritania). To assess to what extent this effort has been yielding tangible results, we looked its impact on both publications and patents in all five countries. To examine in more depth the impact of indicators, we looked at two studies (STI1 and STI2) which are part of the need to start evaluating this effort at policy-making level. But the ultimate objective of both studies was to examine the Algerian innovation system and its impact on the industrial sector.

In more details, the idea of STI 1 started at the ministry of industry level in Algeria through informal discussion in the first stage. The key issue was the lack of a clear idea of the existing innovation system. In other words the concern was the configuration of the existing National System of Innovation (NSI) as defined by Lundvall.[27] and the role of the various players and how could it help promoting innovation in industry. The aim was to Propose an institutional framework and a policy to impulse innovation. The approach used 1/a diagnosis the existing research and innovation system and its performances, 2/a benchmarking with comparators both in the advanced and in the developing world 3/a list of recommendations to build a national system susceptible to impulse innovation in the industrial sector.

The issue of indicators was not at the heart of the preoccupation of the study partly due to the fact there was a lack of demand for STI indicators from policy-makers in Algeria at that time. The National Office of Statistics (ONS), did not produce any STI oriented data. This is often the case in many countries of the South as noted in the Oslo Manual. However, a specific demand made by the ministry of industry related to the need to insert “Industrial technical centres” (ITCs) as an element in the innovation system, Djeflat was taken into consideration. The importance of ITCs can be linked to their role as providers of missing services that could help, usually small firms, that lack R&D capacity to conduct in house R&D projects. It is thus a missing link in the innovation system as highlighted by several authors Gaillard, Mota De Castro[21]

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4 EU/Ministry of industry Evaluation of innovation policies and programs in the industrial sector PROJET N° DZA/B8-4100/1B/98/0708/25
5 TDR: terms of reference of the consultancy contract
6 OECD/Eurostat, The Oslo Manual 2005

### Table 1: Evolution of Innovation Metrics.

| First-generation input indicators (1950s–60s) | Second-generation output indicators (1970s–80s) | Third-generation innovation indicators (1990s) | Fourth-generation process indicators (2000s plus emerging focus) |
|---------------------------------------------|-----------------------------------------------|-----------------------------------------------|---------------------------------------------------------------|
| R&D expenditure | Patents | Innovation surveys | Knowledge |
| S&T personnel | Publications | Indexing | Intangibles |
| Capital | Products | Benchmarking innovation capacity | Networks |
| Tech intensity | Quality change | Knowledge | Demand |

Source: Milbergs and Vonortas (2004)
Nerdrum and Gulbrandsen\textsuperscript{2} and Djeflat.\textsuperscript{3} The study was funded by the European Commission\textsuperscript{2}.

The second study (STI 2)\textsuperscript{4}, originated from a demand expressed by the Department of Innovation (Ministry of Industry) newly created following the recommendations of STI 1. The objective of STI2 was the “Evaluation and update of the Innovation System in the Industry Sector and proposal a strategy for its implementation”. Once more the funding was provided by external source namely UNDP (United Nations Development Program) Support Program for the Implementation of the Industrial Strategy and the Promotion of Investments.

STIA 2 benefited from the progress made at central level (Ministry of higher education and research namely) and the effects of the participation of Algeria in the ASTII process. We will examine, what was the learning done in STIA 2, how it built over a period of seven years (2006–2013) and how the experience was fed into policymaking. An analytical framework is used to assess the learning made at policy-level as shown in Table 2.

We will then examine this trajectory and some key problems and issues beyond the sphere of simple indicators choice and calculation. They are related to context, institutions and mode of governance, some dimensions which are often neglected in the literature and which require more attention in the future.

\textbf{METHODOLOGY}

To address the first question of the impact of polices on indicators, we examined the evolution of the data over a period and tried to connect these with STI policy stages. We used three main data bases: the scopus data base, the Web of Knowledge (WOS) and the Unesco Institute of Statistics (UIS). In addition, national bibliographical data bases were used wherever available. To address the second question, we drew from the specific literature and our personal experience as “observant participant” being involved in both studies, in STI1 as a head of the team and an in STI2 as sole consultant. We used field work on a broad sample of institutions, administrative and professional bodies, and central administration. The Oslo manual of input/output/impact was used as a guiding tool uncritically;\textsuperscript{3} on the input side, we used number of researchers and funding (both public and private) while on the output, we used patents, publications and export of high technology products. International sources were mobilized on top of the official documents from the various institutions. Thirty people were interviewed using a semi-directive questionnaire et included various players from the Ministry of industry and other agencies. The period extended over five months: October 2007 – February 2008.

For STIA 2, more data collected internally and data from international organisations using the input/output/impact indicators method developed in both the Oslo and the Frascati manuals. The role of benchmarking particularly with neighbouring countries was decisive to get adhesion to the STI project. Specific demand to introduce other indicators proper to the Algerian context were formulated by policy-making bodies because of the learning that did take place. In addition, a field survey of key players from a small sample of the most representative institutions was conducted. The study lasted two months from 25 May to June 2013. The results are examined in the section below.

\textbf{RESULTS}

Examining Science and Technology indicators in Maghreb countries: publications and patents.

\textbf{Publications}

Publications in Maghreb countries started increasing substantially following the implementation of the STI policies of the nineties. Figure 1 shows that the takeoff point was between 2000 and 2005 for four main Maghreb countries except for Mauritania. This has been highlighted by several other studies. Thus, an evaluation of the impact of the new policy following law 1998 in Algeria for example made by the Council of Europe, indicated that contributing factors included the development and implementation of twenty seven (27) national research programs, the creation of 639 research laboratories spread over eight major fields, and the mobilization of around 15,500 researchers, (including 2,000 permanent ones) during the period 1998–2002.

As shown by the Scopus data in the period 2010–2020, the number of publications doubled for Algeria and Morocco grew 4 times for Tunisia, and was multiplied by 1.35, and 1.15 respectively Mauritania and Libya (Table 3). Similarly, the UIS data show that the number of scientific publications (excluding social sciences and humanities) has more than doubled in the same period after STI policies were adopted (Table 4). This applies to all five countries, but disparities exist when looking at countries individually (Figure 1).

\begin{table}[h]
\centering
\caption{Matrix of the STI1 and STI2 and the learning process.}
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Indicators} & \textbf{STI 1} & \textbf{STI 2} & \textbf{The learning} \\
\hline
\textbf{Input} & & & \\
\hline
\textbf{Output} & & & \\
\hline
\end{tabular}
\end{table}
In Algeria, scientific publications grew from 731 in 2010 to 1359 in 2020 (Table 3) as shown by Scopus. This is reflected by an increase of publication intensity from 2.685 in 2016 to 8.46 in 2019. This rate of growth in scientific publications is deemed one of the highest globally (SciDev). The country took the first place in some disciplines such as physics, chemistry, engineering and mathematics. Similarly, WOS (Table 4) shows a significant increase from 450 publications in 2010 to 1220 in 2019 (nearly 3 times higher) with the bulk (73.8%) made of journal articles. Nearly 59% are made by Algerian residents and nearly 25% from France. With an average citations per item of 12.67 and an h-index of 100. However, articles produced in international co-authorship amounted to 50.0% on average in the 2002-2018 period mostly with French scholars for historical reasons.

In Libya: Despite the turmoil, making it difficult for the Libyan researchers to operate normally (Tashani), Libya managed to increase its output. Published articles in the Scopus database grew from 488 in 2010 to 319 in 2019 (Table 3). This trend is also shown by WOS (Table 4): publications increased from 158 in 2010 to 379 in 2019, with the bulk (73.2%) made of journal articles with an average citation per item of 11.21 and an h-index of 81. More than 22% are by residents Libyans, 16.4% by residents in USA and 15.8% by residents GB. This is linked to the important diaspora both students and scholars living abroad following the conflict.

In Mauritania, publications increased from 89 in 2010 to 109 in 2019 (Scopus database) (Table 3) WOS shows a modest increase of publications from 53 in 2010 to 99 in 2019 (Table 4) making a total of 1751 the lowest in the region. The bulk (81%) is made of journal articles. The highest proportion (27.8%) are made by non-residents who live in France followed by the residents (18.9%) and then by non-residents in the USA (15.2%). This shows the importance of the scientific and intellectual Diaspora. The average citation index of 10.57 is higher than Libya’s and h-index of 45. The

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majority (90%) is done in co-authorship (Scopus), mostly with French researchers.

In Morocco, the Scopus data base shows an increase of average of 25% of growth during the 2010-2018 from 943 publications in 2010 to 1947 (2.5 times higher) in 2020 (Table 3). This is confirmed by WOS data (Table 4): The number of publications grew from 650 in 2010 to 1643 in 2019, with the bulk (79%) made of journal articles. Fifty per cent are from residents in Morocco while 22% are from France, another indication of the weight of the diaspora in scientific activities. Co-authorship rate excluding social sciences, and humanities reached 38% (2016-2018) with here again, a great proportion with French co-authors for evident historical reasons.

In Tunisia, scopus data base shows a growth of publications from 358 in 2010 to 1369 in 2019 (Table 3). This trend is confirmed by WOS data (Table 4): publication grew from 763 in 2010 to 1320 in 2019 with 82% made of journal articles. Nearly 64.5% are made by residents and 20% by Tunisians living in France. The country took the first position in publication intensity in 2018 (640 per million inhabitants). It has increasingly published in quality publications and ranks first in Africa on the number of publications in relation to GDP (Gross Domestic Product). Co-authorship remains, also relatively important reaching 69% for scientific publication, the majority from France (about 65%) for the same reasons of cultural ties and colonial legacy.

While the probability that STI policies and performances in publication seems to be relatively high, one has to take these performances with some caution, bearing in mind that the “Predatory Publication” virus is also present among scholars in the region. One observation is that they is growing awareness on the part of specialized governing bodies of this phenomenon and steps have been taken to curb it. Thus, the DGRST in Algeria issues each year a list of predatory journals on its website which will not be considered for doctoral submission and career promotion. The other Maghreb countries will no doubt follow shortly as it often happens. On top of that, we looked at other factors, to support the significant growth of publications. Firstly, there has been an intensification of scientific meeting and gatherings (conferences, seminar colloquia etc.) over the last decade mostly in the main Maghreb countries as shown by the Calenda data base (Figure 2).

The stagnation noticed since 2015 in Tunisia is linked no doubt to security and political instability.

The second factor is the rapid increase of journals and periodicals produced locally. The lists are regularly updated by the governing bodies: in Algeria by the DGRST, in Tunisia by the CNUDST and in Morocco by the CNRST. Thus, Morocco has seen its domestic scientific journals grow rapidly: 110 were listed in 2019 with 27% indexed in scopus. In a project form, there is a common platform and an indexing system. Tunisia has a modest number of 16 domestic journals. Algeria is the most advanced with 754 home grown journals listed, nearly 72% in Arabic and the rest are mostly in French. However only 390 are considered as having quality standard. It has already its publication platform, the Algerian Scientific Journal Platform (ASJP) and domestic indexing system: Journals are ranked in three categories A,B and C in decreasing order of quality. Bibliographical data bases have been developed by all five Maghreb countries. At a subregional level, an Arab Citation and Impact Factor (ARCIF) data base was created in 2013 covering 22 Arab countries

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2 Scopus Data base treated by Science Metrix
3 Scopus data base
4 https://www-scopus-com.ressources-electroniques.univ-lille.fr/term/analyzer?rsid=2e7af371ee8dea1582022cc3f0ad99b6&origin=resultslist&rc=s&s=ALL%28Number+of+publications+in+Scopus%29&sort=psf&sd=0&b=35&count=8985&analyse=resultsanalyse&results%2bx%2b%26x%2bgid=61010c724dd75d924a8ecbf1f34fd36
5 http://www.science-metrix.com/sites/default/files/science-metrix/publications/etude_biblioetrique_tunisie_7juin2015.pdf
6 UIS 2019
7 quality also increased shown by the value of the average relative impact factor (FIRM).
8 Science Metrix 2015 http://www-science-metrix.com/sites/default/files/science-metrix/publications/etude_biblioetrique_tunisie_7juin2015.pdf
9 scopus data base
10 http://www.dgrsdz.dz/v1/?fcp=News_A&lid=91
11 Calenda data https://calenda.org/search?q[*:*]&primary=fplace&sort=datemisenligne_date&order=desc&fplace=34946&f2date%5b%5d=2001 visited 08/11/2020
12 National University Center for Scientific and Technical Documentation [Centre National Universitaire de Documentation Scientifique et Technique] French
13 National Center for Scientific and Technical Research [Centre National de Recherche Scientifique et Technique] French
14 http://www.cnudst.rnrt.tn/produits-et-services/valorisation-revues-scientifiques-tunisiennes/
15 http://www.dgrsdz.dz/v1/index.php?fcp=News_A&lid=2
16 http://www.dgrsdz.dz/upload/DDTI/Classement_ARCIF_En.pdf
17 https://emarefa.net/arcl#
including the Maghreb ones. Hosted by the Web of Science, it provides access to bibliographic information and citations to scholarly articles from over 400 Arabic journals. Algeria appears to take the first position in 2020 with 255 journals selected out of a total 681 retained according to DGRST².

The fourth factor is the human potential which grew substantially during the period in the three main countries. USI data show that Morocco increased its number of researchers to 50 142 HC in 2016 (1421 per million inhabitants), Algeria to 96 403 HC in 2017 (2333 per million inhabitants), and Tunisia to 37776 HC in 2016 (3260 par million inhabitants) the highest ratio in the Arab World. Q&A Sci-Dev[3]. The growth is much less important for Mauritania 2223 HC in 2016 and 526 par million inhabitants. Two categories have particularly grown: the numbers of student researchers and female researchers (above world world average). Tunisia has already gone beyond gender parity: 55.4% of female researchers in 2017. These impressive records cannot, however, be extended to the sphere of patenting.

**Patents**

Patenting has grown significantly but at lesser pace in the region indicating difficulties and acute problems in converting research results into innovative products and services.

In Algeria, the total number of patents filed in the period 1983/2006 reached 6,298, of which approximately 91% were made by foreign non-residents firms anxious to protect their industrial property in Algeria. Patents applications by residents have increased more than three times from 76 in 2010 to 252 in 2018⁴ (Table 5), while decreasing for non-residents during the same period from 730 to 521. Patents granted have been decreasing for both categories. Notable is the newly acquired dynamism of Universities and “Grandes Ecoles” with nearly 50% of all patents filled domestically in 2017. Internationally, 7.27% are filed at the USPTO Office (US patents Office) while, 9% were filed at the European Patent Office (EPO) and 5.45% were filed at the PCT (Patent Cooperation Treaty) level. Patent applications/million pop scored 0.9 ranking Algeria 104/140 showing the difficulties it still meets in patenting.

In Libya, the number of patents granted international have been dismal since 2015: two in USPTO, no doubt by diaspora members⁶ (Table 5).

In Mauritania, about 250 patent applications were registered over the period 2001-2015: 94% were made abroad to a foreign intellectual property office, no doubt from members of the Diaspora (Table 5).

In Morocco, patent applications by residents have increased from 135 in 2010 to 187 in 2018⁶ reaching a peak (355) in 2017 (Table 5). (65% come from research centers and universities). The same trend is seen for patents by non-residents growing from 882 in 2009 to 2026 in 2017 as a result of the upsurge of FDI in recent years. Patents granted have been decreasing for non-residents and very erratic for residents. Internationally, the number of patents filed with EPO remains modest 9 in 2018 (World Bank 2019).

In Tunisia, Patents applications by residents have increased from 113 in 2010 to 180 in 2018⁶ reaching a peak (235) in 2016 (Table 5). Patents by non-residents have been decreasing from 508 in 2010 to 2070 in 2018 due to decreasing FDI, following both the political instability and economic crisis. Internationally, patents filing remains relatively weak and erratic: they increased until 2013 (106) and then kept decreasing since then. (4 in 2015 with EPO⁸ 3 in 2018 with USPTO).

While these Figures indicate improving performances, this should not hide the numerous problems met by patenting including the inconsistency of the data and the little attention given to patenting by small firms in general and to international patenting in particular which is not yet in their habits.

| Table 5: Patents filed by Maghreb countries |
|------------------------------------------|
| Years | Algeria | Morocco | Tunisia | Mauritania |
|       | Residents | Non-Residents | Residents | Non-Residents | Residents | Non-Residents | Residents | Non-Residents |
| 2009  | 135       | 856         | 105      | 452         |
| 2010  | 76        | 730         | 152      | 882         | 113       | 508         |
| 2011  | 94        | 803         | 169      | 880         | 137       | 543         | 1         |
| 2012  | 119       | 781         | 197      | 843         | 150       | 476         | 1         |
| 2013  | 118       | 722         | 316      | 828         | 112       | 437         | 3         |
| 2014  | 94        | 719         | 355      | 742         | 142       | 400         |           |
| 2015  | 89        | 716         | 224      | 797         | 180       | 409         | 3         |
| 2016  | 106       | 566         | 237      | 1066        | 235       | 348         |           |
| 2017  | 149       | 594         | 198      | 2026        | 172       | 383         | 3         |
| 2018  | 152       | 521         | 187      | 235         | 180       | 271         |           |

Source: WIPO 2020 – No data for Libya

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² DGRST website: http://www.dgrsdzfz.dz/upload/DDTI/Classement_ARCIF_En.pdf
³ UIS 2018
⁴ https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=DZ
⁵ UIS 2019
⁶ https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=TN
⁷ https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=TN
⁸ WIPO report in 2018
The Algeria Case study

The study was expected to focus on a more pronounced vision of the Sectoral System of Innovation (SSI) as a tool for the foundation of a new policy of competitiveness through “competitive clusters” using new instruments for financing research and innovation.

The STI 1: to explore the NSI and realise the mapping

The results show that STI1 contributed to introduce policymakers at ministerial level to the STI indicators together with the concept of NSI practically unknown at that period and the issues that raises. In this respect, it contributed no doubt to accelerate a number of transformations. The first one was greater awareness raised amongst policy makers (in industry but also in higher education) of the importance of innovation and in particular of the need to have a NIS in good working order. The mapping produced by the MIPI-EU study, with its visual effect, had a particularly pronounced impact on policymakers (Figure 3). It shows all the key players of the Algerian NSI with the ties they had or did not have. As shown by the number of arrows the relations at the time of the study were relatively limited. This made it possible to identify which institution was either totally excluded (in yellow) or only partially included (in pink). We could see thus that banks, foreign firms, professional bodies, and the Diasporas were totally excluded from the interactive game. Universities, research centres, public enterprises and international cooperation were partially included only. Only a limited number of research centers (in brown) were really included.

The second one was enhancing the existing drive for an important institutional restructuring with namely the creation of a specific body dedicated to scientific and technological research at ministerial level: The General Directorate for Scientific Research and Technology (DGRST)\(^2\) in 2010. One of the mandates of DGRST was to produce indicators for S&T country to feed policymaking. Since then, it has become a major department of the Ministry of Higher Education and Research and has acquired an important weight on the mode of governance of the research field. The third implication was the search of active international expertise to help the country implement its STI programme. This prompted Algeria to take part to the ASTII 1 programme in 2008. It took a prominent position in the ASTII 2010 report being listed among the three African countries that produced more than 10 000 papers each in the 1999 – 2009 period together with Nigeria and Kenya, one of the five biggest science producers (highest annual growth rate of 14.0% during the period with similar intensity (between 40 and 70 papers per million inhabitants). It also belonged to the group of the seven countries that consistently produced between 70 and 200 papers per year namely (Algeria, Côte d'Ivoire, Senegal, Cameroon, Tanzania, Zimbabwe, and Ethiopia).

At the Ministry of industry level, the impact was much less visible. On top of the institutional instability level, the study revealed that a dismal proportion of researchers worked in industry: More than 90% of research personnel were in universities. But perhaps more profoundly, there were no resources devoted to the implementation of STI1 policy despite large oil revenues of the country at the time.

STI 2 study to review and deepen the Innovation system in Algeria

The situation changed after STI 1 and a new era seems to have started.

Progress made and the learning in STI2

Notable progress was made in STI 2., though indicators were still drawn from the Oslo manual and the Frascati manual with more emphasis on R&D, they were more refined and more comprehensive OECD report.\(^{[37]}\)

On the input side, the study included: 1/ Estimates of full-time researchers (FTE), 2/ the number of researchers per million inhabitants and in different types of institutions. 3/the diversification of sources of funding for R&D including the business sector, and finally, 4/foreign companies involved in domestic R&D. In this respect, Algeria seems to suffer a significant delay in terms of hosting outsourced R&D from large foreign companies compared to its neighbouring countries namely Morocco, Tunisia, and Egypt. New rules giving foreign companies the right to undertake R&D activities made it possible to integrate them. Hence a certain number were able to set up R&D facilities locally: Lafarge in

\(^{[37]}\) Direction Générale de la Recherche, de la Science et de la Technologie in french
building materials, Henkel in the chemical industry for the production of detergents and Candia and Danone in the agro-food industry for the production of milk and dairy products. Nearly all of them used both foreign expatriates and local personnel in their R&D activities.

On the output side, the changes included: more concise data (residents, non-residents, companies, individual inventors) patents filed internationally namely with USPTO, and percentages of high-tech products exports in total exports of manufactured goods. Specific and additional demand included the need to look at the meso-economic dimension by integrating the Sectorial and the territorial innovation dynamics largely covered in the recent literature highlighted by Malerba and Moulaert and Sekia. The study benefited also from stronger support from officials at both ministries higher education and research and industry as a result of the “learning by participating” to the ASTII programme which took place (Table 6).

Impact of STI 2: Several actions resulted from STI2. Firstly, it soon become evident that the 1998 law was not appropriate anymore perceived mostly a law for research and not for promoting innovation. Industry and enterprises researchers and R&D activities were hardly included in it. This resulted in a new move towards the revision the law to better integrate innovation indicators. Consequently, a new law on the Orientation of Scientific Research and Technological Development was promulgated in 2015. This law sets new rules and principles governing scientific and technological research and the development of innovation. The learning occurred also at the technical level with broadening the spectrum of indicators but also a need to align their use to international standards (Table 6).

Despite all this progress, Algeria was absent from the second leg of the ASTII programme and from the African Innovation Outlook Reports in 2014 and in 2019. This raises several questions related to the institutional dimension of indicators which is often occulted in the literature and which can have a significant impact on the choice and implementation of indicators as shown elsewhere. Several causes can be highlighted.

The first problem is instability of personnel in key institutions. As seen earlier, a relatively important turnover was seen at ministerial level at the industry level. Competence were not maintained permanently due to relatively high turnover. Follow-up could not be guaranteed as representatives kept changing: As an illustration, the training provided by the ASTII programme saw different participants coming in each session which prevented a serious follow-up and cumulative learning, that are needed as noted in the Unesco report. Secondly, often employees sent to attend training sessions were not the right people to attend (bureaucrats) and had no capacity and no background to benefit from these sessions and the basis of their delegation were not always clear. These aspects can constitute therefore important obstacles to develop a real expertise and a vision regarding the integration of indicators.

Table 6: Matrix of the STI 1 and STI2 studies and the learning process.

| Indicators | STI 1 | STI 2 | The learning |
|------------|-------|-------|--------------|
| Input      | Oslo Manual | Oslo/Frascati | More emphasis on R&D and Innovation |
| Human resources | Number of researchers full count | Number of researchers head count and FTE | Estimates of full-time researchers (FTE) - researchers intensity |
| Funding    | Public funding (essentially public funding) | Different sources of funding (Public, and private including foreign) | Foreign capital participation in domestic R&D |
| Others inputs | Industrial technical centers | Industrial technical centers | Industrial technical centers extended to other sectors |
| Output     | Number of patents filed locally | Number of patents filed locally and internationally | Intensity of filing of international patents per institution: USPTO; EPO, |
| Publications | Number of publications | Number of publications with foreign co-authors per million inhabitants | - Use of the Scopus database and its application in the analysis of the quality of publications - co-authorship |
| Export of high tech products | Not included | Export of high tech products (agricultural equipment) | - Diversification of export index - cluster exports |
| Specific indicators | Sectoral and territorial dimension of NSI | Includes sectors and territories in NSI: clusters, technopoles, etc. |

Source: compiled by the author

2 Law No. 15-21 of December 30, 2015

3 According to an ASTII representative: the 16th Globelics Conference, Accra, Ghana, 22/24 October 2018
in STI policy. Thirdly, the trust in synthetic international indicators may have been eroded which explains to some extent why indicators from the South are sometime false, outdated or simply non available due to lack of cooperation of the countries. This is of course on top of the traditional problems of data collection largely covered in the literature Hoogeveen and Pape,[43] Necib.[44] The Global Innovation Index (GII) 2011 showed Algeria in the last position which was criticized by the MESRS as poorly reflecting the reality.

**DISCUSSION**

Looking at these results, it can be concluded that Maghreb countries are indeed performing better than other sub-regions in Africa on some output indicators and a real quantitative and qualitative jump has been witnessed in the last decade for publications. This did not however translate adequately into patenting lagging well behind. STI policies, despite several shortcomings seem to start yielding positive results. However, some observations can be made. Firstly, regarding publications, the dominant and growing rate of co-authorship North–South, while giving valuable opportunities to learn to local researchers raise several fundamental questions of appropriation. There is a danger to see a “dependent science” rising in the region and the continent. Weak patenting has been attributed in particular to the lack of culture of industrial property among firms Hassan[45] but also to the weakness of support services and the weakness of the IP environment (specialized lawyers and patent engineers in particular).

Secondly, having good indicators is only part of the story; the main issue is how to make it sustainable through the implication of actors and institutions and how to make them adhere to the process over time.

Thirdly, indicators need wide acceptation through policy dialogue. Often the indicators were produced to comply with international standards, decided unilaterally by one prominent institution without taking into account the needs of the users. Policy dialogue is sometimes absent between major key players in the Maghreb such as the Ministry of higher education and research and the Ministry of industry. It is also absent with the other stakeholders such as research centres who feel they are not consulted and work in isolation as expressed by a social science research centre in Algeria[5]. This raises the major issue of inclusiveness in indicators settings. This goes along with the conclusions of the work done by Dutrenit et al.

Fourthly foreign firms participation to in R&D input/output indicators while being encouraged by the new Africa which opens to the rest of the world, is a relatively new phenomenon and it is not clear whether R&D indicators should be counted at the domestic level. Unesco[42] suggested in 2010, these R&D expenditures of foreign-controlled entities should be captured as a distinct sub-sector. Beyond a certain level, foreign involvement in R&D might reduce the control of national R&D policy and STI policy.

Finally, the power game over issues related to indicators and mandates is not to be neglected: indeed as it often occurs in countries of the South, the low level of good governance at State’s level can bring institutional overlap and inter-institutional conflict and confrontation. We have seen that phenomenon in all three major Maghreb countries. The issue of who is legitimate and whose mandate it is to conduct the innovation function was often raised. This controversy stems from the fact that often R&D and innovation take place at the level of the firm (Ministry of industry) while the majority of researchers are located in universities and research centers (Ministry of higher education). In particular, who should produce the legal and regulatory instruments for innovation creating sometimes tensions between the two entities. This element may have been determinant in the lack of participation of Algeria in the ASTII 3 process and in the African Innovation Outlook Reports.

**CONCLUSION**

Maghreb countries have made a significant progress in STI indicators in recent years namely with regards to publications. This is the result of several factors namely a significant improvement of STI development policy, an increased awareness of governing bodies of the importance of indicators, the building of domestic capabilities to collect the necessary STI data and the rapid extension of the major international databases (Scopus, WOS, Scimago etc.). This is probably what gives them a prominent position compared to the rest of Africa where these capabilities are missing. However, this position remains fragile as shown by missing indicators in many global statistics and sometimes outdated ones. Obvious policy implications require that STI indicators become one of the priorities in future agendas.

The Algerian case study shows that, indicators can have a significant implication STI policy-making in a relatively short term as a result of the learning which takes place at the level of dedicated institutions. The state of indicators in African countries does not reflect solely the state of the tools and statistics but also the state of the relations between key players and institutions in the NSI. In Maghreb countries the bureaucrat’s view of indicators overwhelmingly dominates the expert’s views making this process non inclusive. It is time that this balance goes in favor of knowledge and true expertise convening the large scientific and technical diaspora the Maghreb and Africa, as a whole, have.

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2 Conclusions of a seminar held by the DGRST in June 2019 in cooperation with CREAD the Center for Research in Applied Economics
The role of international organization in building capacity in Africa should be stressed in view of the relatively rapid progress made by Maghreb countries in the usage of STI indicators in recent years. The ASTI program has shown its usefulness. To make it sustainable, countries need to become regular participants in this process. Maghreb countries have not always been present, showing a certain crisis of confidence. To be able to properly implement STISA 2024, there is a need to restore confidence in the African home-grown indicators that the ASTI program has been promoting.

Finally, indicators should solve the issue of governance reducing turnover within key institutions while giving higher incentive. This is particularly important at this stage of “Innovation systems in construction” where most African countries are. The challenge of comparability versus efficient implementation considering specific circumstances of the continent should be addressed.

If it is possible to build capacity in indicators use, production and improvement, however the issue is to make it sustainable.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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