Science Profile of Islamic Countries (II)

Analysis of Publications

Summary
The current document is a part of the second phase of an ongoing effort to prepare a comprehensive Science Profile of the OIC countries. The first part comprised 8 leading countries selected on the basis of the magnitude of their total published work in Impact Factor journals. Its also included a summary of comparison of various scientometry indicators for these countries. The second phase comprises of countries selected on the same criterion as well as giving consideration to regional representation. The work presented here examines the research activities of these countries based on an analysis of the data of their research publications in different fields. The targets in particular are to identify their respective areas of focus, strengths, weaknesses, international linkages, more active institutions etc. In this context we use standard scientometry indicators to assess the significance and quality of the research. Secondary focus is on getting an idea of the impact of the scientific research on the economic activities of respective countries. We emphasize that our analysis does not attempt to rank countries or institutions. We identify a number of parameters that shed light from both quantitative and qualitative aspects and it is up to the experts in respective disciplines to draw conclusions about relative merit, to the extent that such data, or parameters derived from it, can be used to make such inferences. It is suggested for science policy makers and funding bodies who refer to this report that publication numbers, citations, impact factors, while useful in comparing the output within a discipline should not be used to make comparisons, particularly of quality, between various disciplines. It is also suggested that due importance should be given to the discussions on the Nature Science Index to understand the extent of contributions of OIC institutions in high value publications.

Section I: Introduction
A. Range and Scope of Study:
Part I of the Science Profile:
The first part reported on the following countries selected as defined in the following:
1. The top seven countries identified on the basis of the total number of publications in various discipline of Science and Technology that are defined in detail later.
   a. Iran
   b. Turkey
   c. Saudi Arabia
   d. Malaysia
   e. Egypt
   f. Pakistan
   g. Tunisia

2. Kazakhstan: The host country of the 1st Summit of the OIC on Science and Technology, being held at Astana, 9-11, September, 2017.

PART II of the Science Profile:
The second part of this report continues with the three remaining countries of the top ten, viz. Algeria, Nigeria and Indonesia. Additionally, it will include countries selected to represent different geographical regions of the OIC e.g.

   a. Uganda (West and Central Africa)
   b. Azerbaijan (Central and western Asia)
   c. Morocco and Jordan (MENA)
   d. Bangladesh (South East Asia)

The third part of the report will cover some of the remaining OIC countries.
A. Extent of data analysed in this study

Our data and its analysis has been confined to the following period and major fields:

a. The period 2014-2016
b. The fields of research covered under:
   1. Life Sciences
   2. Chemistry
   3. Materials Science and Nanotechnology
   4. Physics
   5. Mathematics
   6. Engineering
   7. Earth Sciences

(Medical research is not included in our analysis)

B. Targets

We have tried to ensure that for each country and each discipline we are able to,

1. present an accurate quantitative picture of research work in various disciplines taking special care to avoid repetition or multiple counting i.e. avoiding counting the same publications under different disciplines, as is very common in most such analyses.
2. Obtain an idea of the qualitative nature/scientific significance of the publications based on high impact publications, citations and other means wherever available.
3. Correlating the scientific output with the patents awarded in each discipline as an indicator of the impact of research on economic activity.

Section II: Methodology

A. Databases used: Due to accessibility for us as well as the general familiarity of the scientific community with the Web of Science (WoS) and its terminologies we have utilized it as our main data base. Our WoS search is limited to articles and reviews and we do not take into account proceedings, letters, books etc. (Limited amount of data on Conference Proceedings has been included for the field of Engineering). Additional data where available has been derived from the Nature Science Index while Statnano database has been referred to for some details e.g. nano-related commercial activity Economic indicators have been obtained from the World Bank Database and the UIS (UNESCO Institute of Statistics).

B. Classification of publications into various disciplines:

This is the most challenging part of the work and we have taken elaborate steps to ensure that publications are classified sensibly and uniquely. To appreciate the significance of this step it is essential to understand the way the Web of Science classifies a particular publication. Firstly, we note that all publications in the WoS data base are classified by it on the basis of the classification(s) of the journal it is published in.

All fields of research (e.g. chemistry, physics, mathematics etc) are further sub-divided into sub-specializations. There are two different sets of these sub-divisions, one known as the Web of Science Categories while the other is known as Research Areas. The former is a more detailed
division of a particular subject into sub-divisions while the latter is a more condensed version with several WoS categories often being grouped under one Research Area.

Each journal is classified by WoS into one or more Categories and one or more Research Areas. In case the journal is classified under multiple categories (or Research Areas) there is a hierarchy of classifications. For example, a particular journal A may be classified as follows: physics, materials science, chemistry. In this example, whether one searches for publications in physics or chemistry or materials science, the same paper would be counted by WoS in the search for each of these categories and hence leads to multiple counting of the same publication. This is where the general error in enumerating publications in different Categories or Research Areas creeps in.

To address this problem viz. to ensure that each publication is counted only once, irrespective of the many categories it may be classified in, we have used the methodology described here. The data of the publications from a country in a particular field (say Physics) are down loaded from the WoS data base by selecting the relevant categories for the field (e.g. physics, optics, spectroscopy etc. for physics). This data is downloaded in an HTML format and then imported into MS Word. Macros are especially designed in MS Word by our team to extract the required information from the data imported from the HTML files. For each publication the information is collected under seven heads and transferred eventually to an excel data base for further analysis. These seven heads are: 1. title of publication, 2. journal name, 3. authors, 4. institutes, 5. times cited, 6. publication year, 7. web of science categories and research areas. The WoS categories information of the publication is used to identify the very first classification (in case of multiple classifications) and the paper is so classified, while the remaining information is used for other cataloguing and analyses purposes. The flow chart shown on the following page depicts this process schematically.

In the example quoted earlier for multiple classification, the said paper which was classified by WoS as physics, chemistry, materials science would be classified by us only under physics, as that is its first classification. In case of a single classification of a journal there is of course no ambiguity about where the particular paper belongs. Articles that have e.g. the classification chemistry, physics, materials science would be classified as a chemistry publication and analysed there.

While our detailed analysis is confined to the publications selected as detailed above, we also give the total number of publications under a web of science category irrespective of the level where the category appears in the classification of a publication. This is done to enable a check between our numbers and those provided by other analysts for the same subject categories where 1st place selection is not adopted.

The above compiled data includes the name of the publishing journal, and using this the impact factor of the said journal is picked by the software from a separate database and included in the information of the said paper. (Publications for which no Impact Factor was available were excluded from the later analysis, though counted towards the total number of publications in a category). Thus the information about the institution, impact factor, discipline and sub-discipline, citations received, etc. are all available and can be compiled.
Flowchart: Schematic Representation of Methodology

A consequence of sorting publications by 1st place classification, we noticed, is that many publications emanating e.g. from Mathematics departments end up being classified as Engineering or Mechanics or Thermodynamics or physics, depending on the primary classification of the journal they are published in. We stress however that to the best of our knowledge no publications are lost in this process of identifying the primary category as described above. They are sometimes diverted to categories that the researcher may not immediately identify himself with. e.g. a mathematician may find his publication listed under engineering and a physicist may find his listed under chemistry.

We have preferred to use the WoS Categories for separation of a field into sub-fields for almost all cases except for the case of Biology and its related disciplines where the WoS Research Areas have been used for classification of publications. This was necessary since the number of WoS Categories for Life Sciences was too large to be accommodated. Due to the diversity of subjects covered under Life Sciences we have divided this field into three sub-categories and each is analysed separately. The classification for these three sub-categories follows the Glanzel and Schubert Classification*. Details of the WoS Categories or Research Areas covered under each of the focused fields are detailed in the next Section.

*A new classification scheme of science fields and sub-fields designed for scientometric evaluation purposes. W. Glanzel and A. Schubert, Scientometrics, 56 No.3. (2003) 357-367
Section III: The fields Studied and the WoS Categories covered within each field

1. **Physics**
   WoS Categories:
   Astronomy and astrophysics; Physics, Particles and Fields; Optics; Spectroscopy; Physics, Condensed Matter; Physics, Applied; Physics, Multidisciplinary; Physics, Atomic Molecular and Chemical Physics, Fluids and Plasmas; Physics Mathematical; Physics Nuclear.

2. **Chemistry**
   WoS Categories:
   Physical Chemistry; Analytical Chemistry; Applied Chemistry; Inorganic & Nuclear Chemistry; Organic Chemistry; Medicinal Chemistry; Polymer Science; Electrochemistry; Crystallography; Multidisciplinary Chemistry

3. **Mathematics**
   WoS Categories:
   Mathematics; Applied Mathematics; Mathematics Interdisciplinary Applications; Statistics and Probability.

4. **Life Sciences**
   Category A: Agriculture and Environment
   Category B: Biology and Biosciences
   Category C: Pharmacological Research

   **Category A: Agriculture and Environment**
   WoS Research Areas:
   Agriculture, Biodiversity & Conservation, Demography, Entomology, Environmental Sciences & Ecology, Fisheries, Food Science & Technology, Forestry, Marine & Freshwater Biology, Oceanography, Veterinary Sciences

   **Category B: Biology and Biosciences**
   Wos Research Areas:
   Biochemistry & Molecular Biology, Biophysics, Biotechnology & Applied Microbiology, Cell Biology, Developmental Biology, Evolutionary Biology, Genetics & Heredity, Immunology, Life Sciences & Biomedicine, Mathematical & Computational Biology, Microbiology, Mycology, Parasitology, Reproductive Biology, Toxicology, Virology, Plant Sciences, Zoology

   **Category C: Pharmacological Research**
   WoS Research Areas:
   Integrative & Complementary Medicine, Legal Medicine, Pharmacology & Pharmacy, Research & Experimental Medicine

5. **Engineering**
   **Engineering Electrical**
   WoS Categories:
   Electrical/Electronics, Telecommunications, Automation Control System, Robotics, Communication

   **Computer Science**
   WoS Categories:
   Computer Science Theory Methods, Computer Science Information System, Computer Science Artificial Intelligence, Computer Sciences Interdisciplinary, Computer Science Software Engineering, Computer Science Cybernetics, Computer Science Hardware Architecture
Mechanical Engineering
WoS Categories
Engineering Mechanical, Engineering Manufacturing, Engineering Industrial, Metallurgy Engineering, Engineering Aerospace, Marine Engineering, Ocean Engineering, Thermodynamics, Instrumentation, Mechanics

Chemical Engineering
WoS Categories
Chemical Engineering, Energy Fuels

Civil and Structural Engineering
WoS Categories:
Civil Structural, Engineering Civil, Construction Building Technology, Transportation, Transportation Science

Petroleum Mineral/ Mining Engineering
WoS Categories
Engineering Geological, Engineering Petroleum, Mineralogy, Mining Mineral Processing

6. Earth Sciences
WoS categories:
Geology, Geochemistry, Geophysics, Mineralogy, Palaeontology, Geosciences Multidisciplinary, Geography, Geography Physical

7. Materials Science, Nanoscience and Nanotechnology
WoS Categories:
Biomaterials, Ceramics, MS Characterization & Testing, MS Coating & Films, Composites, MS Multidisciplinary, MS Paper & Wood, MS Textiles); Nanoscience and nanotechnology

Section IV: List of the data compiled and analysed for each country and each field

The data for each country has been collected and analysed for each of the fields identified in Section III, as described below.

1. Identification of total number of publications in a Web of Science category; separation into 1st place (A) and lower place classification. (as described in Section II). All subsequent analysis performed on the set of publications (A).

2. Determination of year wise number of publications for the years 2014-2016 and Average Growth Rate. (AGR)=(change in publications between 2014 and 2016/number of publication in 2014) X 100%.

3. Separation of publications into their various sub-fields (WoS categories or WoS Research Areas) and identification of more active sub-fields.

4. Impact Factor wise distribution of the publications and average impact factor per publication.

5. Impact Factor wise analysis for each sub-field and identification of sub-fields with higher I.F. publications. (Only where number of publications in field are sufficiently high).

6. Identification of the ten most published-in journals for the field; their respective sub-fields, and Impact Factors.

7. Identification of the ten highest Impact Factor journals in which publications have taken place and the sub-fields they correspond to.
8. List of the ten highest Impact Factor papers published; the publishing journals and their respective impact factors, the numbers of citations received by these papers and the contributing institutions from the specific country.
9. Distribution of publications with respect to the numbers of received citations.
10. Identification of institutions publishing the larger number of publications.
11. Identification of a country’s main international collaborations in general, and the collaborations within OIC countries, in particular.
12. Nature Science Index Data for Physics, Chemistry, Life Sciences and Earth Sciences categories and estimating the country’s own contribution to elite publications.
14. A summarized general discussion on both quantitative and qualitative aspects.

Section V: Assessing the quality of published work

Before proceeding further, we stress that publication numbers, citations, impact factors, while useful in a limited sense should not be used to make comparisons of quality between various disciplines. Nor can the quality of scientific research be adequately gauged by such parameters alone. In general, the more esoteric the area of research, the less it is populated and consequently its related journals have lower impact factors and publications therein also acquire lesser citations etc. This does not in general diminish the quality of the research. But as a general rule, publishing in higher impact journals is a more competitive and challenging proposition. Similarly, in general, higher numbers of citations for a publication testify to the originality or significance of the work for a wider audience. Thus average Impact Factors or average numbers of citations per paper have different significance for different fields and even sub-fields and this must be borne in mind when drawing inferences from the data.

Within the afore mentioned limitations two criteria have been adopted by us to gauge the significance of publications. They are as follows:

a. Using the WoS indices: The first relies on the WoS indices, such as the impact factor of the journals being published in and the frequency of publications in such journals. A breakdown of the publications into various impact factor ranges has been presented for each sub-discipline. Similarly, the WoS data has been analysed in terms of the number of times a publication has been cited and the data for each country and discipline has been analysed in terms of the number of publications that fall within various 'times cited' ranges.

b. Utilizing the Nature Science Index:
To compensate to some extent for the heavy reliance on quantitative factors obtained from the WoS data base we have also used the Nature Science Index (NSI) as an indicator of the qualitative standing of the published work. The NSI takes into consideration only those publications appearing in an elite set of 68 journals that have been identified by leading scientists as the most credible and important in their respective fields. These journals and the associated categories are divided into the following four groups:

a. Physical Sciences
b. Life Sciences
c. Chemistry
d. Earth and Environmental Sciences
As such the NSI does not evaluate the work done in the fields of Mathematics or Engineering. A list of the journals included in the NSI is available on the Nature Science Index Website. Some details of the NSI assessment parameters are given here.

The Nature Index consists of 3 parts viz.
   a. Article Count (AC),
   b. Fractional Count (FC)
   c. Weighed fractional Count (WFC).
A brief explanation of these indices is as follows:

A. Article Count (AC): The number of publications from a country or institute appearing in the chosen set of journals over a given period of time. Each distinct publication is counted as one, i.e. one or more contributing authors are from a given country, irrespective of the number of collaborating institutions and scientists.

B. Fractional Count (FC): It is used to estimate the contribution of the authors of a given institution or country to the publications in which their names appear in Nature’s selected journals. It takes into account the percentage of authors from an institution or country and the number of affiliated institutions per article. For computational purposes all authors are considered to have contributed equally to the article. The maximum combined FC for any article is 1.0.

C. Weighed fractional Count (WFC): This count is generated from the FC by weighing the articles in the selected Astrophysics and Astronomy journals by 0.2 to take into account the relatively higher number of publications in these selected journals.

D. The ratio of FC to AC, i.e. ratio of Fractional Count to Article Count for the publications of a given country in a given field has been used by us as estimating the contribution of a given country’s authors to the said publications. e.g. An AC of 50 and FC of 30 would yield FC/AC ratio equal to 0.6 and would indicate that the contribution of the said country to these 50 publications is about 60% on the average.

Hence the NSI and the parameters derived from it give us an idea of the most significant work emanating from a country, defined as work that is published in this elite set of journals. It also gives us, most importantly, an estimate of the actual contribution of the concerned country in those publications. This becomes particularly important in the case of publications emerging from very large international collaborations as e.g. in most cases in experimental high energy physics and many cases in genetics.

**Concluding Remarks**

It is hoped that this effort on the part of COMSTEC will serve the desired purpose of enabling researchers and policy makers in OIC countries to assess the status of their research. Hopefully it will enable them to place the quantity and quality of work emanating from their respective countries in a comparative context, both with respect to other OIC countries and indeed with more scientifically developed countries. It is hoped that detailed information about institutions publishing in higher quality journals will enable their counterparts in other OIC countries to form collaborations of mutual benefit. The Report may also sensitize academics as well as policy makers to note the general disconnect between academic research and indigenization of technology in OIC countries.
While we have made careful efforts to check the correctness of our data and its analysis, in an enterprise of such extant and complexity some errors may still have escaped our notice. We remain open to corrections in case any such errors are pointed out to us.

Dr. S. Khurshid Hasanain
COMSTECH, Islamabad
(April 2018)
Relevant Indicators for Science & Technology

Four OIC Countries for Scientific Research Papers, 2006-2016

Publications trend over the past eleven years for Four of the OIC countries covered in Part 2 of Science Publication Report

Gross Domestic Expenditure on R&D (GERD), as % of GDP of 33 OIC Countries

Source: UNESCO, UIS
Note: The graph reflects the latest available data

Country bars shown red are the countries analyzed in the current report. Note: Values are quoted as percentages of GDP hence reflect the relative significance accorded to R&D by respective countries.
Relevant Indicators for Science & Technology

Number of Full Time R&D Personnel, 2015 or latest

Ref: UNESCO, UIS-STI (Oct. 2016)

<table>
<thead>
<tr>
<th>Country</th>
<th>Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey</td>
<td>115,448</td>
</tr>
<tr>
<td>Egypt</td>
<td>101,519</td>
</tr>
<tr>
<td>Pakistan</td>
<td>111,601</td>
</tr>
<tr>
<td>Malaysia</td>
<td>82,360</td>
</tr>
<tr>
<td>Iran</td>
<td>80,386</td>
</tr>
<tr>
<td>Indonesia</td>
<td>51,514</td>
</tr>
<tr>
<td>Morocco</td>
<td>37,860</td>
</tr>
<tr>
<td>Tunisia</td>
<td>21,294</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>17,586</td>
</tr>
<tr>
<td>UAE</td>
<td>11,400</td>
</tr>
<tr>
<td>Nigeria</td>
<td>11,330</td>
</tr>
<tr>
<td>Algeria</td>
<td>7,331</td>
</tr>
<tr>
<td>Senegal</td>
<td>5,642</td>
</tr>
<tr>
<td>Jordan</td>
<td>3,548</td>
</tr>
</tbody>
</table>

Countries in Part 2

Publications according to NATURE Index Data (1st March 2017 to 28th February 2018)

<table>
<thead>
<tr>
<th>#</th>
<th>Indicators</th>
<th>Algeria</th>
<th>Indonesia</th>
<th>Jordan</th>
<th>Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC</td>
<td>12</td>
<td>50</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>FC</td>
<td>2.98</td>
<td>6.32</td>
<td>1.31</td>
<td>1.87</td>
</tr>
<tr>
<td>3</td>
<td>WFC</td>
<td>2.12</td>
<td>6.22</td>
<td>1.15</td>
<td>0.68</td>
</tr>
</tbody>
</table>

AC: Article Count
FC: Fractional Count
WFC: Weighted Fractional Count
(These terms are defined in the Introduction of the Report)

Source: Nature Science Index

Countries in Part 1

Publications according to NATURE Index Data (1st November 2015 to October 2016)

<table>
<thead>
<tr>
<th>#</th>
<th>Indicators</th>
<th>Iran</th>
<th>Turkey</th>
<th>Saudi Arabia</th>
<th>Malaysia</th>
<th>Egypt</th>
<th>Pakistan</th>
<th>Tunisia</th>
<th>Kazakhstan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC</td>
<td>235</td>
<td>339</td>
<td>456</td>
<td>123</td>
<td>147</td>
<td>162</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>FC</td>
<td>106.49</td>
<td>74.34</td>
<td>102.25</td>
<td>10.71</td>
<td>13.7</td>
<td>32.8</td>
<td>3.15</td>
<td>7.99</td>
</tr>
<tr>
<td>3</td>
<td>WFC</td>
<td>87.11</td>
<td>62.78</td>
<td>98.34</td>
<td>9.75</td>
<td>10.21</td>
<td>29.28</td>
<td>2.57</td>
<td>6.04</td>
</tr>
</tbody>
</table>

Source: Nature Science Index

Information in this document is the property of COMSTECH and may not be copied without the written consent of COMSTECH (www.comstech.org)