Impact of GDP, Spending on R&D, Number of Universities and Scientific Journals on Research Publications among Asian Countries

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Abstract

Objectives: This study aimed to compare the impact of Gross Domestic Product (GDP) per capita, spending on Research and Development (R&D), number of universities, and Indexed Scientific Journals on total number of research documents (papers), citations per document and Hirsch index (H-index) in various science and social science subjects among Asian countries.

Materials and Methods: In this study, 40 Asian countries were included. The information regarding Asian countries, their GDP per capita, spending on R&D, total number of universities and indexed scientific journals were collected. We recorded the bibliometric indicators, including total number of research documents, citations per document and H-index in various science and social sciences subjects during the period 1996–2011. The main sources for information were World Bank, Scimago/Scopus and Web of Science; Thomson Reuters.

Results: The mean per capita GDP for all the Asian countries is 14448.31±2854.40 US$, yearly per capita spending on R&D 0.64±0.16 US$, number of universities 72.37±18.32 and mean number of ISI indexed journal per country is 17.97±7.35. The mean of research documents published in various science and social science subjects among all the Asian countries during the period 1996–2011 is 158086.92±69204.09; citations per document 8.67±0.48; and H-index 122.8±19.21. Spending on R&D, number of universities and indexed journals have a positive correlation with number of published documents, citations per document and H-index in various science and social science subjects. However, there was no association between the per capita GDP and research outcomes.

Conclusion: The Asian countries who spend more on R&D have a large number of universities and scientific indexed journals produced more in research outcomes including total number of research publication, citations per documents and H-index in various science and social science subjects.

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Introduction

Research in science and social science sectors play an important role in the country’s communal and economic growth along with long-term sustainable development. The research innovations in science and social sciences contribute to improving the living standards and quality of life. Considering the rising significance of research in economic growth of a nation, many countries are reducing dependency on their natural resources and swiftly moving towards knowledge-based economy. Investment in research is important for the progress in science and technology as well as for social and economic development. [1].

To recognize and quantify the progress of research, bibliometric indicators are essential tools to understand the size, growth and global spread of research. Bibliometric indicators are frequently practiced to measure the scientific productivity, visibility and capacity of research publications with global science. These indicators are mainly based on the number of scientific research documents (research papers) published and global citations received (cited by other researchers). Bibliometric indicators quantify the quantity, quality of research output and there are structural indicators as well which assess the association between authors, publications and areas of research in universal science [2].

Science and technology cannot exist if researchers do not evidence or publish their experimental findings and results.
Scientific writing and its outcome in the form of research publication are essential components of academic excellence. Scientific publications are a key indicator of the development of a country, and a healthy scientific research environment is a prerequisite for scientific and economic progress [3].

| Countries        | GDP in US$ | Spending on R&D (% of total GDP) | Universities | Journals |
|------------------|------------|----------------------------------|--------------|----------|
| Armenia          | 3184.33    | 0.220                            | 12           | 3        |
| Azerbaijan       | 5427.03    | 0.193                            | 26           | 1        |
| Bahrain          | 18867.55   | 0.2                              | 11           | 2        |
| Bangladesh       | 607.96     | 0.080                            | 80           | 4        |
| Brunei Darussalam| 32063.81   | 0.040                            | 3            | 0        |
| Cambodia         | 764.05     | 0.100                            | 20           | 0        |
| China            | 3938.31    | 1.418                            | 376          | 155      |
| Cyprus           | 29733.22   | 0.438                            | 15           | 0        |
| Georgia          | 2698.83    | 0.213                            | 13           | 0        |
| Hong Kong        | 31372.38   | 0.775                            | 12           | 0        |
| India            | 1214.78    | 0.762                            | 321          | 100      |
| Indonesia        | 2550.01    | 0.083                            | 174          | 0        |
| Iran             | 4402.87    | 0.728                            | 186          | 39       |
| Iraq             | 2582.35    | 0.100                            | 35           | 0        |
| Israel           | 27340.55   | 4.544                            | 21           | 13       |
| Japan            | 40101.26   | 3.431                            | 567          | 236      |
| Jordan           | 3976.35    | 0.421                            | 29           | 1        |
| Kazakhstan       | 8552.92    | 0.224                            | 24           | 0        |
| Kuwait           | 50566.56   | 0.091                            | 6            | 3        |
| Lebanon          | 8146.10    | 0.300                            | 24           | 0        |
| Macao            | 46672.87   | 0.086                            | 3            | 0        |
| Malaysia         | 7987.01    | 0.635                            | 146          | 10       |
| Mongolia         | 2143.60    | 0.230                            | 10           | 0        |
| Nepal            | 477.89     | 0.100                            | 7            | 1        |
| Oman             | 20524.01   | 0.090                            | 11           | 0        |
| Pakistan         | 1002.35    | 0.569                            | 128          | 13       |
| Palestine        | 1194.33    | 0.100                            | 15           | 0        |
| Philippines      | 1991.05    | 0.110                            | 113          | 6        |
| Qatar            | 75175.82   | 2.000                            | 2            | 0        |
| Saudi Arabia     | 16861.75   | 0.058                            | 61           | 6        |
| Singapore        | 38934.97   | 2.401                            | 6            | 50       |
| South Korea      | 20108.20   | 3.193                            | 142          | 0        |
| Sri Lanka        | 2184.17    | 0.144                            | 24           | 1        |
| Syria            | 2590.35    | 0.200                            | 15           | 0        |
| Thailand         | 4211.33    | 0.231                            | 65           | 8        |
| Turkey           | 9729.07    | 0.719                            | 86           | 54       |
| United Arab Emirates | 44544.27 | 0.150                          | 31           | 12       |
| Uzbekistan       | 1191.56    | 0.120                            | 22           | 1        |
| Viet Nam         | 1135.71    | 0.120                            | 41           | 0        |
| Yemen            | 1181.09    | 0.110                            | 12           | 0        |
| Mean             | 14448.31   | 0.64                             | 72.37        | 17.97    |
| SEM              | 2854.40    | 0.16                             | 18.32        | 7.35     |

Main sources of retrieving information [6–8], Data expressed as Mean±SEM.
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The research information seeking behavior is essential in economic success of a country [4]. In order to achieve long-term and sustainable economic growth, spending on education, research and development is essential to produce a substantial amount of innovative research. There is a direct relationship...
between research and the overall development of nations. Keeping all these facts in mind, the present study aimed to compare the impact of Gross Domestic Product (GDP), spending on Research and Development (R&D), number of universities and indexed scientific journals in Institute of Scientific Information (ISI) on bibliometric indicators including total number of research documents (research papers), citations per document (referenced/cited in the literature), and Hirsch index (H-index) an index to quantify an individual’s scientific research output, in various science and social science subjects among Asian countries.

Materials and Methods

This observational study was conducted in the Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia. In this study, we reviewed all the 50 Asian countries [5]. The countries who published less than 100 publications per annum during the period 1996–2011 were excluded from the study. Finally, for this study, we included 40 Asian countries. The information regarding all the Asian countries, their average per capita GDP and total GDP for the last five years, spending on R&D were collected from the World Bank sources [6], and the data about number of universities were collected from the World Association of Universities [7]. The information regarding scientific journals which are indexed in Institute of Scientific Information (ISI) was obtained from Web of Science, Institute of Scientific Information (ISI) Journal Citation Reports (Thomson Reuters) [8]. Bibliometric indicators in Science and Social Science subjects during the period 1996–2011 were recorded from SCI-mago/Scopus [9]. For ISI indexed journals, we logged on to Web of Science, the territory was selected, country name was entered, and the names of journals along with impact factors for each Asian country were retrieved. For the recording of bibliometric indicators, research outcome in all world scientific journals indexed in Scopus was recorded. In SCI-mago site, region and country was selected, subject field “Science” and “Social Sciences” were selected and detailed information regarding the bibliometric indicators including total number of research papers (documents), citations per document and H-index in science and social science subjects among Asian countries were obtained.

Statistical Analysis

The data were analyzed by using Statistical Package for the Social Sciences (SPSS) software version 18. Data were expressed as Mean ± Standard Error of Mean (SEM). The Pearson correlation coefficient and Kendall’s rank correlation coefficient were calculated to find the strength of relation between different variables. p-value <0.05 was considered significant.

Results

The total numbers of Asian countries included in this study are 40. The mean per capita GDP for all the Asian countries is $14,448.31 \pm 2854.40$ US$. The yearly per capita spending on R&D is $0.64 \pm 0.16$ US$, number of universities $72.37 \pm 18.32$ and mean number of ISI indexed journal per country is $17.97 \pm 7.35$ (Table 1).

Table 2 shows the number of total documents published in various science and social sciences subjects among the Asian countries during the period 1996–2011 as 158086.92 ± 69204.09; citations per document 8.68 ± 4.8; and H-index 122.8 ± 19.21.

Table 3 demonstrates the Pearson correlation coefficient between the mean GDP per capita, spending on R&D, number of universities, indexed journals and total number of research documents, citations per document, H-index in various science and social sciences subjects among Asian countries during the period 1996–2011.
We found that spending on R&D has a positive correlation with total number of published documents ($r = 0.480; P = 0.002$) [Fig. 1], citations per document ($r = 0.429; P = 0.006$) and H-Index ($r = 0.805; P = 0.0001$) [Table 3]. In addition, we found that number of universities has a positive correlation with total number of documents ($r = 0.841; P = 0.0001$) [Fig. 2], and H-Index ($r = 0.755; P = 0.0001$) [Table 3]. Moreover, we also found that ISI indexed journals have a positive correlation with total number of published documents ($r = 0.893; P = 0.0001$) [Fig. 3], and H-Index ($r = 0.801; P = 0.0001$) [Table 3]. However, we did not find strong positive correlation between per capita GDP and research outcomes [Table 3, Fig. 4].

In addition to Pearson correlation coefficient, we also applied the Kendall’s tau ($\tau$) rank correlation coefficient between different variables. We found that spending on R&D has a positive Kendall’s tau ($\tau$) rank correlation coefficient with total number of published documents ($\tau = 0.447; P = 0.0001$) and H-Index ($\tau = 0.457; P = 0.0001$). In addition, we found that number of universities has a positive correlation with total number of documents ($\tau = 0.532; P = 0.0001$) and H-Index ($\tau = 0.475; P = 0.0001$). Furthermore, we found that ISI indexed journals have a positive correlation with total number of documents ($\tau = 0.601; P = 0.0001$) and H-Index ($\tau = 0.536; P = 0.0001$) [Table 4].

**Discussion**

The role of research in driving the productivity and pecuniary growth is important in which knowledge is central to economic development. Few Asian countries experienced a shift from their natural resources, agriculture, and primary commodities dependent economy to knowledge-based economy [10–11].

In this study, we compared the impact of GDP per capita, spending on R&D, number of universities and scientific indexed journals on bibliometric indicators including total number of research documents, citations per document and H-index in various science and social sciences subjects during the period 1996–2011. We found a positive correlation between the spending on R&D, number of universities, indexed journals and total number of research documents, citations per document and H-index in various science and social sciences subjects in Asian countries. However, we did not find an association between per capita GDP and research outcomes (Table 3–4).

GDP is the economic growth measured in terms of an increase in the size of the country economy. It is the main indicator used to

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**Table 3.** Pearson correlation coefficient between GDP per capita, spending on R&D as % of total GDP, number of universities, indexed journals and total number of research documents, citations per document, H-index in various science and social sciences subjects among Asian countries during the period 1996–2011.

| Parameters                  | Research Documents | Citation per documents | H-Index |
|-----------------------------|--------------------|------------------------|---------|
| GDP per capita US$\dollar$  | $r = 0.050$        | $r = 0.064$            | $r = 0.189$ |
|                            | $p = 0.761$        | $p = 0.694$            | $p = 0.242$ |
| Spending on R&D             | $r = 0.480$        | $r = 0.429$            | $r = 0.805$ |
|                            | $p = 0.002$        | $p = 0.006$            | $p = 0.0001$ |
| Universities               | $r = 0.841$        | $r = 0.063$            | $r = 0.755$ |
|                            | $p = 0.0001$       | $p = 0.699$            | $p = 0.0001$ |
| Indexed journals           | $r = 0.893$        | $r = 0.085$            | $r = 0.801$ |
|                            | $p = 0.0001$       | $p = 0.602$            | $p = 0.0001$ |

$r =$ Pearson correlation coefficient.

$p =$ p-value.

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gauge the strength of a country’s economy and represents the total value of all goods and services produced over a specific time period. We found no correlation between per capita GDP and total number of documents, citations per document and H-Index in various science and social science subjects (Table 3–4, Fig. 5). The Asian countries with the highest GDP are Qatar, Kuwait, Macao, and United Arab Emirates and the countries with the lowest GDP are Cambodia, Bangladesh and Nepal (Table 1). It is well-known that Qatar, Kuwait, Macao, and United Arab Emirates are among the richest in Asia, but their research publications are in contrast to their GDP (Fig. 5). In Japan, South Korea and Turkey research growth is comparable to their GDP. Although GDP of China and India is low, yet they are producing high in research outcomes (Fig. 5). In the present study, we found that there is no difference in the research outcomes between the countries with high GDP compared to the countries with a low GDP. The results of the present study show that, the research outcome does not depend upon GDP, but it actually depends on how much percentage of total GDP is being spent on R&D. The investment in R&D is a major factor in determining the contribution that research can make to scientific progress and innovation. The investment in R&D is associated with high rates of research outcomes which lead to knowledge based economy.

The national innovative capacity is highly dependent on R&D investment [12–13]. The Asian countries spending more on R&D are Israel, Japan, South Korea, Singapore, Qatar and to some extent, China, Saudi Arabia, Hong Kong, India, Iran and Turkey. These countries are spending more on R&D and generating more in research outcomes. The annual spending on R&D in Asian countries especially the wealthy Arab states is just 0.2% of the gross national product compared to the world average of 1.4% [14–15]. It has also been reported that average annual spending on R&D by most of the Organization of Islamic Countries (OIC) in Asia was 0.34% of GDP, much lower than the global average over the same period as 2.3% [15]. However, in recent years, few Arab states in Asia including Qatar, Saudi Arabia, Kuwait and UAE resolved to spend more on R&D. The average spending on

Figure 2. Correlation coefficient between the number of universities and total number of research documents in various science and social science subjects among Asian countries during the period 1996–2011.
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Figure 3. Correlation coefficient between scientific indexed journals and total number of research documents in various science and social science subjects among Asian countries during the period 1996–2011.
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R&D in the Asian countries is 0.64 ± 0.16 (Table 1), it is still small, but it shows a positive correlation with research outcomes.

Zhang [16] conducted a study on the research relationship between expenditure for science and technology activities and economic growth in China and reported that R&D input adds great contribution in the economic growth development. The R&D efforts provide better opportunities to create new knowledge and enhance capabilities to integrate and exploit external knowledge. Therefore, investing greater amount on R&D generate strong research and technological based capabilities in terms of their processes and product innovations and enhances overall performance.

Helpenny et al. [17] conducted a study to examine the geographic origin of publications and link between the percentages of GDP spent on R&D. They found that the percentage of GDP spent on R&D was positively correlated with the number of publications (r = 0.603, P < 0.001). Similarly, in the present study, we found a positive correlation between the spending on R&D and research outcomes in various science and social science subjects. Our study findings are in agreement with the results of Helpenny et al. [17]. Anwar and Abu Baker [15] have reported that most of the Asian Arab world countries lack researchers, scientists and technicians, and have an average of nine scientists, engineers and technicians per thousand people, compared with a world average of forty-one. The obvious reason is meager spending on R&D hence the majority of Asian countries have less number of researchers and scientists. Furthermore, it has been reported that from Asian countries, a large number of the research scholars, scientists migrate to other continents including North America, Europe and Australia. A more recent report published in Nature indicates that, 12% researchers, scientists from China, 37% from India have migrated to UK, USA and Australia [18]. Moreover, majority of researchers and scientists from other Asian countries including Pakistan, Bangladesh and Jordan is also moving to cross-continent.

The scientific travel is not only about empirical observation but the scientists also carry with them sort of scientific attestation. This large figure of researchers immigrating to other countries creates a gap. Besides this situation, we found a positive correlation between spending on R&D and research outcomes (Table 3, Fig. 1).

In Asian countries, the number of universities and research institutions is also not satisfactory enough, the mean number of universities per country in Asia is 72.37 ± 18.32, and the mean population of these countries is 101334431.8 ± 144636036.51. The number of universities is very small compared to the population of these countries. In spite of this situation, in the present study we found a positive correlation between the number of universities and H-Index in science and social science subjects among the Asian countries (Table 3, 4, Fig. 2).

### Table 4. Kendall’s rank correlation coefficient between GDP per capita, spending on R&D, number of universities, indexed journals and total number of research documents, citations per document, H-index in various science and social sciences subjects among Asian countries during the period 1996–2011.

| Parameters              | Documents | Citation per documents | H-Index |
|-------------------------|-----------|------------------------|---------|
| GDP per capita (US$)    | $\tau = 0.136$ | $\tau = -0.032$ | $\tau = 0.107$ |
|                         | $p = 0.217$    | $p = 0.778$      | $p = 0.333$   |
| Spending on R&D         | $\tau = 0.447$ | $\tau = 0.139$ | $\tau = 0.457$ |
|                         | $p < 0.0001$   | $p = 0.226$      | $p < 0.0001$   |
| Universities           | $\tau = 0.532$ | $\tau = 0.027$ | $\tau = 0.475$ |
|                         | $p < 0.0001$   | $p = 0.814$      | $p < 0.0001$   |
| Indexed journals        | $\tau = 0.601$ | $\tau = 0.02$  | $\tau = 0.536$ |
|                         | $p < 0.0001$   | $p = 0.872$      | $p < 0.0001$   |

$\tau$ (tau) = Kendall’s rank correlation coefficient.

$P$ = p value.

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Figure 4. Correlation coefficient between per capita GDP and total number of research documents in various science and social science subjects among Asian countries during the period 1996–2011.

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Choung and Hwang [19] reported that universities play an important role in increasing number of research papers in the ISI database and the related research activities of the universities supported the development of industrial technologies. Similarly, in the present study we found a positive association between number of universities and an increasing number of ISI research papers. This is an established fact that the basic place of the research is the universities, we believe, Asian countries must increase number of universities and eventually the research outcome will further enhance.

In addition to reviewing GDP, spending on R&D, number of universities, we also reviewed the ISI indexed journals in Asian countries. The countries in Asia having a large number of ISI indexed journals are as follows: Japan 236, China 155, India 100, Singapore 55, Turkey 54, and Iran 39 (Table 1). The mean number of journals in all the Asian countries is 17.97 ± 7.35 (Table 1) with an average impact factor 0.58. It is evident that the scientific journals; especially the ISI indexed journals, are less in number. Many do not have on-line access, and are not indexed in major bibliographic/citation databases. The majority of indexed journals, however, do not have a stable presence in popular scientific databases. The Arab Asian countries are producing less than 0.5% of scientific research papers appearing in the 200 leading medical journals. Furthermore, the number of publications, original writings and translations per million people is about 0.05 in the Arab Asian countries, compared with an average of 0.15 worldwide and 0.6 in industrialized countries [20]. In the present study, we found that the total number of ISI indexed journal in Asian countries is 719 (Table 1). This shows that the total number of ISI indexed journals in Asian countries is even less than a single European country like UK that has 1637 ISI indexed journals [8]. We found a positive correlation between the number of scientific journals and total number of research documents and H-index; it shows that countries having more ISI Indexed journals are producing more research papers (Table 3, 4, Fig.3).

Study Strengths and Limitations
The main strengths of this study are that; we selected the large number of Asian countries, employed all the promising parameters to compare the research outcomes which play potential role in the development of research such as GDP, spending on R&D, number of universities, and ISI-Indexed Journals. We collected the information regarding the Asian countries, their GDP, spending on R&D, from very reliable source of the World Bank. The data about number of universities were gained from the World Association of Universities. The information regarding the ISI-indexed scientific journals and Bibliometric indicators in various science and social sciences subjects were obtained from the Institute of Scientific Information [ISI], Web of Science, Journal Citation Reports (Thomson Reuters), and SCI-imago web. These are highly reliable sources in scientific literature. However, sometimes citation count tools may mis-cite a paper, and there are chances of same paper may appear twice with slightly different details. This may inflate the number of citation counts. This is one of the limitations of the present study.

Conclusion
This is the first study which has analyzed the productivity and visibility of research papers in Asian countries. We found that spending on R&D, number of universities and scientific indexed journals have a positive association with the total number of research documents, citations per documents and H-index in various science and social science subjects. However, we did not find an association between the per capita GDP and research outcomes. It shows that the Asian countries who are spending more on R&D, have more universities and ISI indexed journals are producing significant volume of research papers. It is suggested that Asian countries need to recognize the importance of scientific research for social and economic development. They also need to establish more universities, increase funding for R&D and launch more scientific journals and must get indexed with ISI. Continuing efforts must be taken to develop the policy to promote research culture. These steps will augment the research oriented education and culture and ultimately the research outcome will increase and bring the scientific, social as well as economic development in the region.

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Author Contributions
Conceived and designed the experiments: SAM. Performed the experiments: SAM AAM AMU ANM SZZ. Analyzed the data: AMU. Wrote the paper: SAM AMU.

References
1. Macilwain C (2010) What science is really worth. Nature News, 465: 682–684.
2. Durieux Y, Gevenois PA (2010) Bibliometric indicators: quality measurements of scientific publication. Radiology, 255 (2): 342–351.
3. Moe SA, Al-Naadi M (2007) Right path of publishing a scientific paper to a right journal. Academic paper based case study. Pakistan Journal of Medical Sciences, 23(6): 946–949.
4. Perin T, Moat HS, Stanley HE, Bishop SR (2012) Quantifying the Advantage of Looking Forward. Scientific Reports, 2: 350; 1–2.
5. Geographical region and composition: United Nation Statistical division. Available: http://unstats.un.org/unsd/methods/m49/m49regin.htm#asia. Accessed Dec 16, 2012.
6. World Bank. Available: http://data.worldbank.org/indicator/NY.GDP.PCAP. CD. Accessed Nov 26, 2012.
7. International association of universities, the list of universities of the world. Available: http://www.iau-aiu.net/content/list-uir. Accessed Nov 26 2012.
8. Journal citation report, ISI web of Knowledge. Available: http://webofknowledge.com/JCR/JCR?PointOfEntry=Home&SID=4FeKpokbnHkLlmE1OGe. Accessed Nov 28, 2012.
9. SCI-mago Journal and country ranking. Available: http://www.scimagojr.com/countrysearch.php?region=Asiatic%20Region. Accessed Nov 26, 2012.
10. Asgari B, Wong CY (2007) Depicting technology and economic development of modern Malaysia. Asian Journal of Technology Innovation, 15(1), 167–193.
11. Wong CY, Koh KL (2012) The pathway of development: science and technology of NIEs and selected Asian emerging economies. Scientometrics, 92: 523–548.
12. Hu MC, Mathews JA (2005) National innovative capacity in East Asia. Research Policy, 34(9): 1322–1349.
13. Hu MC, Tseng CY (2007) Technological interdependence and knowledge diffusion in the building of national innovative capacity: The role of Taiwan’s chemical. Industry, Technological Forecasting and Social Change, 74 (3): 298–312.
14. Masood E (2002) Arab science: Blooms in the desert. Nature, 416 (6877): 120–122.
15. Anwar MA, Abu Bakar AI (1997) Current state of science and technology in the Muslim world. Scientometrics, 40: 23.
16. Zhang L (2012) Research on Relationship between Expenditure for Science & Technology Activities and Economic Growth in China. Advanced Materials Research, 433–440: 1528–1534.
17. Halpenny D, Burke J, McNeill G, Snow A, Torreggiani WC (2010) Geographic origin of publications in radiological journals as a function of GDP and percentage of GDP spent on research, Acad Radiol. 17 (8): 768–71.
18. Richard Van Norden (2012) Global mobility: Science on the move, Nature, 490 (7420): 326–329.
19. Chung JY, Hwang HR (2000) National systems of innovation: Institutional linkages and performances in the case of Korea and Taiwan. Scientometrics, 48 (3): 413–426.
20. Al-Khader AA (2004) Enhancing research productivity in the Arab world, Saudi Med J. 25(10): 1323–7.