CURRENT STANCE OF SCIENCE AND TECHNOLOGY IN OIC COUNTRIES

ORGANISATION OF ISLAMIC COOPERATION
STATISTICAL, ECONOMIC AND SOCIAL RESEARCH
AND TRAINING CENTRE FOR ISLAMIC COUNTRIES

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INTRODUCTION

Research in science and technology is of great importance and key to progress towards a knowledge-based, or an innovation-driven economy. It promotes better understanding on different aspects of life and helps to improve the standard of living by creating new knowledge and technological innovation. Today, there is severe competition among countries to become the most competitive and knowledge-based economy in the world. Gaining a *comparative advantage* against other countries, which is of particular importance to the OIC member countries in catching-up within this competitive world of knowledge economy, depends on how well they perform in research activities.

This paper presents an overview of the current developments in the OIC member countries in the field of research and development (R&D) and science & technology (S&T). In particular, the current stance of the OIC member countries compared to the rest of the world, in terms of fundamental indicators of research and scientific development, such as human resources in R&D, R&D expenditures, high technology exports, scientific publications and patent applications, is analysed.

Some broad policy recommendations are presented in the context of our comparative analysis. Most importantly, R&D should be stimulated through government and private sector initiatives, and coordination among OIC countries. Networking opportunities among the OIC member countries need to be facilitated through programmes such as the Framework Programme of the European Union, to support research and technological development in the Islamic world and to promote joint research initiatives among the member countries.

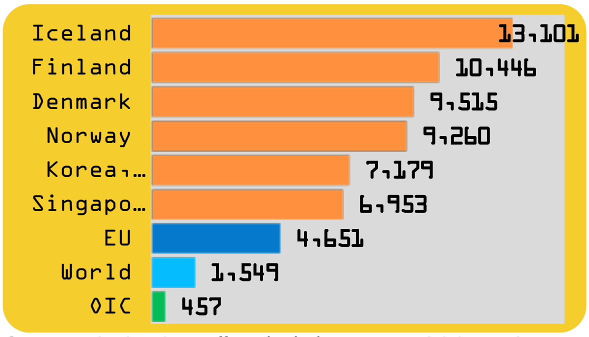
Additionally, joint research and investment in the emerging scientific fields and technologies, such as nanotechnology, should be initiated in a timely manner to make use of the immense benefits associated with early investment in the critical sectors. Higher education and academic research need to be supported through more government funds. There is also a dire need for promoting and enhancing patent development, particularly in small and medium-sized enterprises. Last but not least, infrastructure for information and communication technologies should be improved for a wider and effective participation of the society in general, and the youth in particular, in different components of research and development in OIC member countries.

1 RESEARCH AND DEVELOPMENT

1.1 Human Resources in Research and Development

The availability of abundant and highly qualified researchers is an essential condition to foster innovation and promote the scientific and technological development of a country. However, statistics indicate that OIC member countries, on average, fall well behind the world average in terms of researchers per million people: 457 vs. 1,549, respectively[1].

Figure 1.1 Researchers per Million People*



Source: SESRIC staff calculations; UNESCO, UIS Data Centre
***** Headcount data for the most recent year available.

The gap gets smaller when compared to non-OIC developing countries with an average of 827 researchers per million. However, the gap is even larger when compared to the EU average of 4,651, which is more than 10 times of the OIC average. More strikingly, per million inhabitants, Norway, Denmark, Finland and Iceland have at least 20 times more researchers than the OIC average (see Figure 1.1).

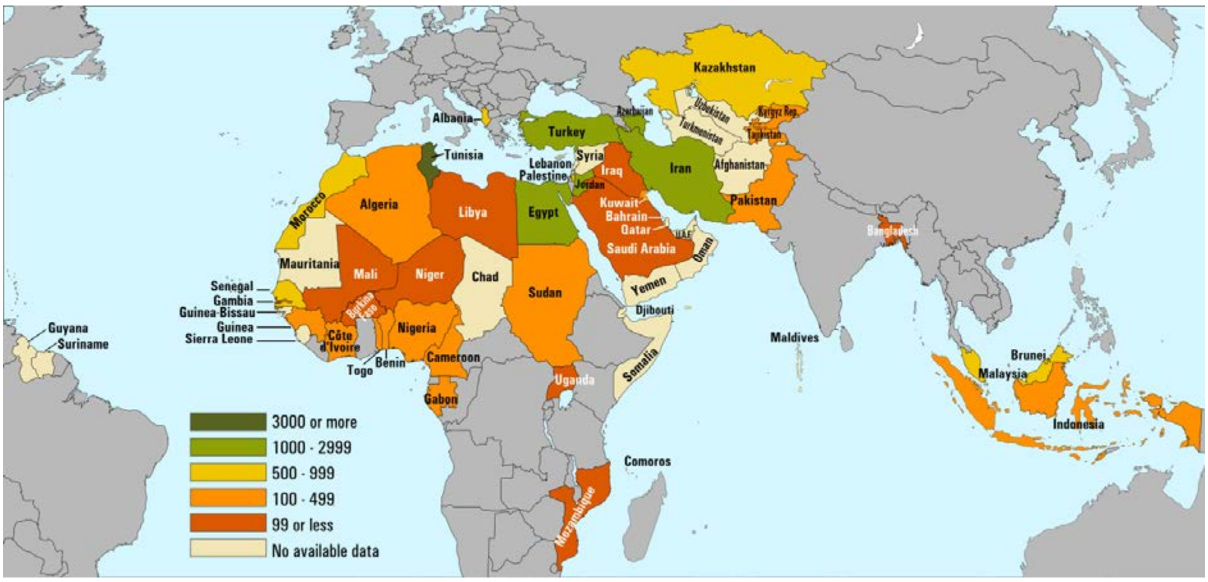
Map 1.1 illustrates the distribution of researchers employed in R&D and reveals the following observations:

- Only six of the 37 member countries (for which data are available) have more than 1,000 researchers per million people: Tunisia (3,240), Jordan (1,934), Turkey (1,715), Iran (1,491), Azerbaijan (1,218) and Egypt (1,018).
- Among these, the values for Tunisia, Jordan and Turkey are also above the world average.
- Nine member countries have less than 100 researchers per million people, most of which are in Sub-Saharan Africa.
- Large disparity exists among the member countries; while Tunisia has 3,240 researchers per million inhabitants, Niger has only 10 researchers.

1.1.1 Women in Research Activities

In the last decades, women, with better access to

Map 1.1 Distribution of Researchers per Million People*



Source: SESRIC staff calculations; UNESCO, UIS Data Centre
***** Headcount data for the most recent year available.

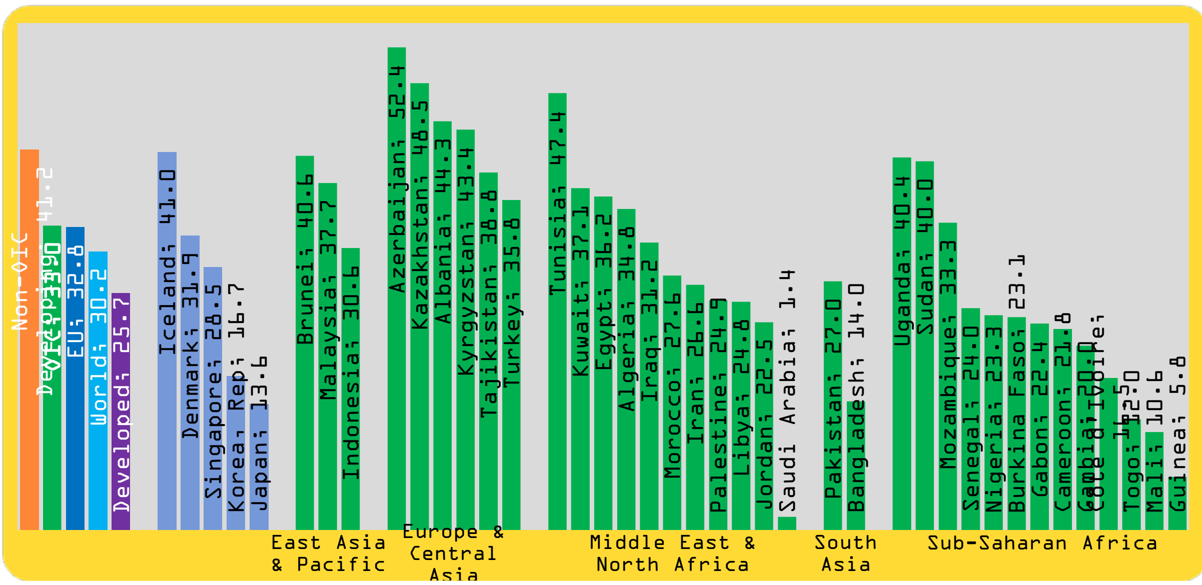
[1] Figures are the weighted averages for the countries with available data.

training and education facilities, thanks to the rising awareness on gender in/equality, have become more qualified and motivated to participate in the labour force. Nevertheless, the progress achieved so far in the field of R&D seems unsatisfactory neither globally nor at the OIC level. In only 16 of the countries in the world, the female researchers are more than the male researchers. In Myanmar and Bolivia, the percentage of female researchers is as high as 85% and 63.2% of total researchers, respectively. Women, in the OIC, represent around 33% of the total researchers, slightly higher than the world average of 30.3%[2]. The gap is larger when compared to the average of non-OIC developing countries (41.2%) and some developed countries, such as Iceland, but still the OIC average is higher than that of the EU average and some other developed countries, such as Singapore, Republic of Korea and Japan (see Figure 1.2).

With respect to the data demonstrated in Figure 1.2, the following observations can be drawn:

- The share of women in total researchers is above the world average in 17 of the 35 OIC member countries with available data. 15 of them outperform the EU average as well.
- According to regional averages, OIC members in Europe & Central Asia, East Asia & the Pacific and Middle East & North Africa report higher rates of women researchers, often above the world average.
- Intra-regional difference is wider in the Middle East and North Africa: On one hand, there are countries like Tunisia, Kuwait, Egypt, and Algeria where women represent more than

Figure 1.2 Women as a Share of Total Researchers (%)*



Source: SESRIC staff calculations; UNESCO, UIS Data Centre
***** Headcount data for the most recent year available.

[2] Aggregate calculations are based on countries with available headcount data – for the most recent year available between 1997 and 2010.

35% of total researchers; on the other hand, there also are countries where women's share is less than 5% as in the case of Saudi Arabia.

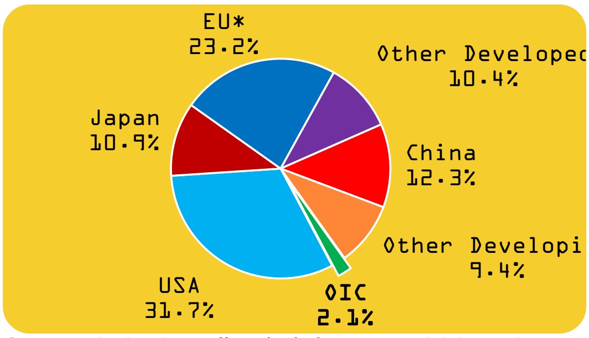
- Azerbaijan is the only member country that has more women researchers than men. With a female researchers' share of 52.4%, it is also the seventh country in the world. Kazakhstan, Tunisia, Albania, Kyrgyzstan, Brunei, Uganda and Sudan–all with over 40% women researchers– are also close to achieving gender parity.

1.2 Expenditures of Research and Development

1.2.1 Research and Development Intensity

Today, more than 76% of the global R&D expenditures is spent by developed countries, of which 31.7% by the USA, 23.2% by the EU, and 10.9% by Japan (Figure 1.3). The OIC countries account for only 2.1% of the world total Gross Domestic Expenditures on R&D (GERD), or 8.8% of the total GERD of developing countries whereas the GERD of China is more than 5 times the OIC total. With GERD worth of $32.8 billion in 2010, Russia, alone, spends more than the OIC total of $26.6 billion.

Figure 1.3 GERD, % of World Total



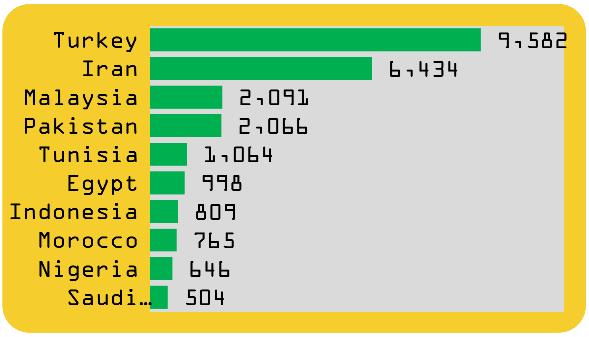
Source: SESRIC staff calculations; UNESCO, UIS Data Centre

Among the member countries, Turkey is the leading country by spending $9.6 billion on R&D. (Figure 1.4) Adding the GERD of Iran in the amount of $6.4 billion, the GERD of these two countries make up 60.3% of OIC total. Malaysia, Pakistan and Tunisia are the other member countries with GERD over $1 billion.

Nevertheless, what is more important than the volume of GERD is its weight in the total expenditures or, in other words, in GDP. Accordingly, R&D intensity (GERD as a percentage of GDP) is a widely used indicator of S&T activities. It reflects the innovative capacity of a country in that a higher R&D intensity indicates that relatively more resources are devoted to the development of new products or production processes.

In this connection, the OIC Ten-Year Programme of Action to Meet the Challenges Facing the Muslim Ummah in the 21st Century, which was adopted at the Third Extraordinary Session of the Islamic Summit Conference held in Makkah al Mukarramah, Kingdom

Figure 1.4 Top 10 OIC Countries by GERD (Million $)



Source: SESRIC staff calculations; UNESCO, UIS Data Centre

of Saudi Arabia, in December 2005, calls upon Islamic countries "*to encourage research and development programmes, taking into account that the global percentage of this activity is 2% of the Gross Domestic Product (GDP), and request Member States to ensure that their individual contribution is not inferior to half of this percentage*" (OIC-TYPOA, 1995, Part 2, Section V, Article 4).

Nevertheless, available data show that OIC member countries' spending on R&D activities is significantly lower than the world average and still far away from the implied target of 1% of GDP by 2015. R&D intensity for the OIC member countries averages 0.81%, which is quite lower than the EU average of 1.87% and the world average of 2.22% as well as the targeted rate of 1% (Figure 1.5).

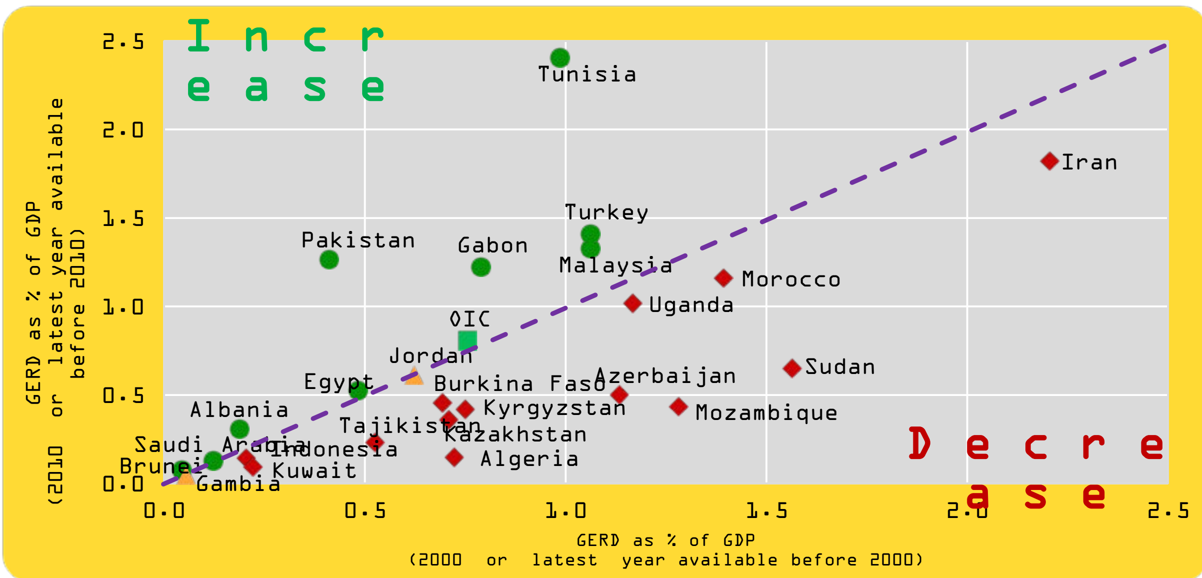
Regarding the R&D intensity in the OIC member countries, the situation can be summarized as below:

- Among the member countries with available data, Tunisia, Iran, Turkey, Malaysia, Pakistan, Gabon, Morocco, and Uganda have met the target so far, reporting levels of R&D intensity above 1%. The lowest spending level is recorded for Gambia (0.05%).
- Most of the member countries spend less than 0.7% of GDP on R&D.
- Among the few Sub-Saharan members that can provide data, Uganda, with 1.03% R&D intensity, is the only country to spend above the OIC average.
- Considering the figures in some other developed countries like Korea (5.24%) and Finland (3.2%), USA (2.87%) and Japan (2.73%), all of which owe their economic development largely to investments in advanced technology, OIC member countries need to allocate much more resources to R&D activities to bridge the gap with developed countries.

Figure 1.6 illustrates the change in R&D intensity between 2000 and 2010 for the OIC member countries for which data are available. Accordingly;

- In most of the member countries, a decrease in R&D intensity is evident.
- Tunisia, Pakistan, Gabon, Turkey, Malaysia and Albania managed to increase their R&D intensity significantly. It was more than doubled in Pakistan and the increase in Tunisia was almost over 1.5 folds. Accordingly, although Iran, Sudan, and Morocco had the highest R&D intensity rates in 2000, Tunisia outperformed them while Turkey caught up with Morocco by 2010.

Figure 1.6 Research and Development Intensity Trends



Source: SESRIC staff calculations; UNESCO, UIS Data Centre

- Sudan, Mozambique, Azerbaijan, Algeria and Iran reported a significant decrease in their R&D intensity.
- The average for the OIC countries increased by 0.06 percentage point during the period examined. It is higher than that for the EU members (-0.27 percentage point) and that for the world (0.02 percentage point).

1.2.2 Research and Development Expenditures per Capita

"R&D expenditures per capita" is a frequently used indicator to make comparisons among countries in terms of the level of spending on R&D. Accordingly, the following observations can be drawn for OIC countries from Figure 1.7, which presents data for the change in this indicator in the last decade.

- Of the OIC countries for which data are available, only Turkey ($131.7) and Tunisia ($102.7), have per capita levels above one hundred dollars. They are followed by Gabon ($91.9), Iran ($89.1), and Malaysia ($78.6).
- The lowest rates are recorded for Mozambique, Tajikistan, and Gambia, all with less than $2 of R&D expenditures per capita.
- For OIC countries with available data, the average R&D expenditures per capita are calculated as $29.6, which is well below the world average of $244 and the EU average of $601. In Luxemburg and Finland this figure is even above $1,400, which is higher than GDP per capita values of twenty seven OIC countries in 2010.
- From 2000 to 2010, R&D expenditures per capita increased by an average of only $20 for OIC countries, compared to $100 for the world and $229 for the EU, which could be considered as another source and indicator of divergence between OIC countries and the rest of the world with respect to scientific development.
- In the same period, Turkey, Tunisia, Iran and Malaysia were the top four countries to have most increased their GERD per capita, $87.3, $80.1, $50.7 and $36.2, respectively.
- In addition to these, 14 OIC countries also reported increases in their GERD per capita ranging between $17.9 (Kazakhstan) and $0.9 (Tajikistan).
- On the other hand, three of the 24 OIC countries with available data reported decline in their GERD per capita. Algeria experienced the sharpest decline in this period so that its GERD per capita fell down to $4.8.

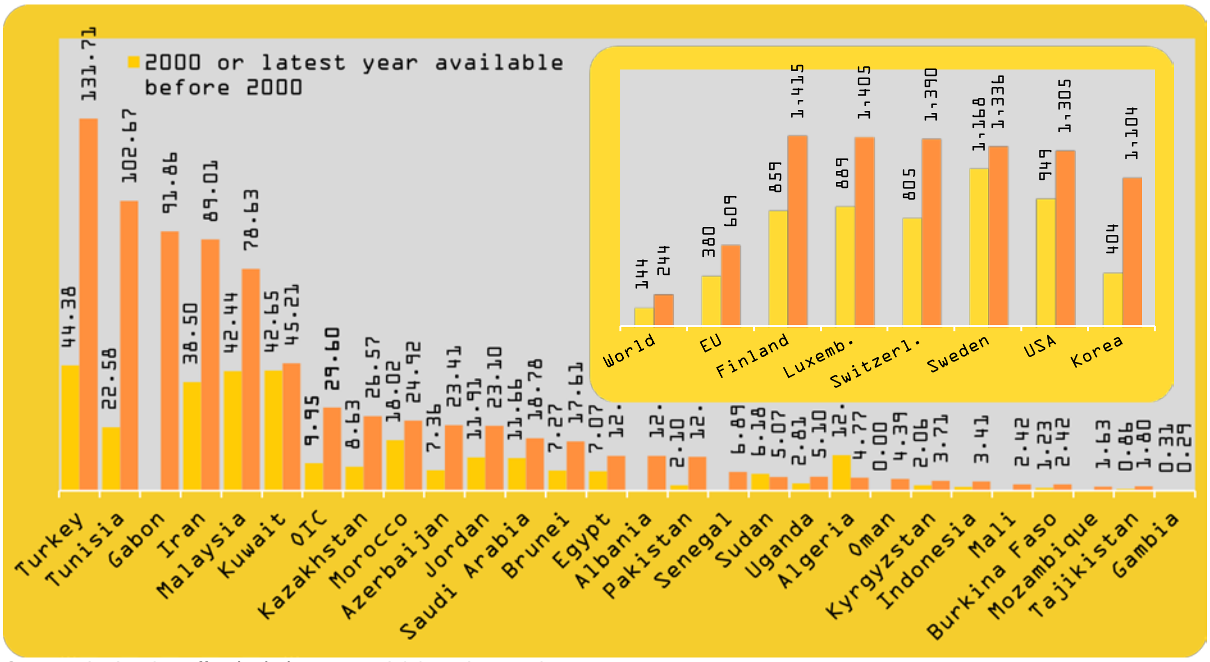
1.2.3 Research and Development Expenditures by Sector

Given that GERD is the sum of R&D expenditures of the performing sectors, it is useful to disaggregate it into individual sectors to see how much R&D is performed by each sector. This sectoral disaggregation is based on the United Nations classification that defines four major sectors of performance: Government, Business Enterprise, Higher Education, and Private Non-Profit. In this respect, Figure 1.8 presents the distribution of GERD among these sectors in the OIC member countries for which data are available. The figures are based on total available resources, regardless of their source of funds.

As illustrated in Figure 1.8, sectoral distribution of GERD can be summarized as follows:

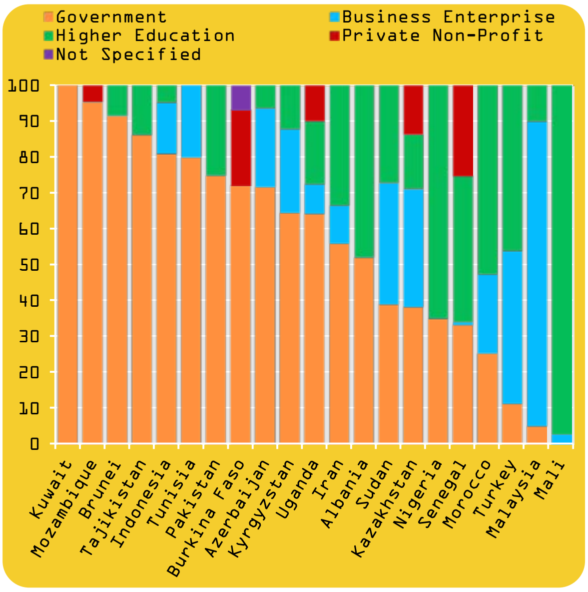
- In most of the OIC member countries (13 out of 21 with available data), more than 50% of GERD is spent by government sector. This share reaches up to 100% in Kuwait and exceeds 90% in Mozambique, and Brunei.
- Despite having a share of less than 50%, government sector in Sudan and Kazakhstan is the dominant sector, spending more on R&D than the other sectors do.
- The share of Business Enterprise in GERD is highest in Malaysia with 84.9%. Moreover, in, Turkey, Sudan, and Kazakhstan; Business Enterprise accounts for more than 30% of the GERD.
- GERD of Business Enterprise is either unavailable or available only at negligible levels in Kuwait, Mozambique, Brunei, Tajikistan, Pakistan, Burkina Faso, Albania, Nigeria, Senegal, and Mali.
- Higher Education is the leading sector in Mali, Nigeria, Morocco, Turkey, and Senegal, accounting respectively for 97.0%, 64.8%, 52.4%, 46.1%, and 40.7% of the total GERD. Furthermore, more than one quarter of the GERD in Iran, Sudan, and Pakistan is also performed by this sector.

Figure 1.7 Research and Development Expenditures per Capita (PPP $)



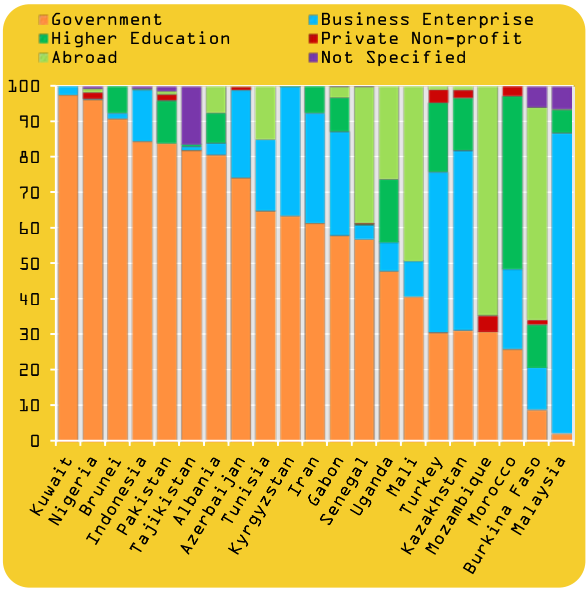
Source: SESRIC staff calculations; UNESCO, UIS Data Centre

Figure 1.8 Distribution of GERD by Sector of Performance (%)*



Source: SESRIC staff calculations; UNESCO, UIS Data Centre
* Data for the most recent year available.

Figure 1.9 Distribution of GERD by Source of Funds (%)*



Source: SESRIC staff calculations; UNESCO, UIS Data Centre
* Data for the most recent year available.

- The share of R&D expenditures by the Private Non-Profit sector is at a negligible level in all of the member countries except in Senegal (25%), Burkina Faso (21.1%), Kazakhstan (13.5%), Uganda (9.9%), and Mozambique (4.6%).

1.2.4 Research and Development Expenditures by Source of Funds

Figure 1.9 presents information on the funding sources of R&D in OIC member countries. Source distribution of the GERD has been made again on a sectoral basis as specified above, yet including additionally the funds from abroad.

Accordingly, given the data illustrated in Figure 1.9, the situation in OIC member countries can be summarized in the following observations:

- In most of the OIC member countries, R&D is mainly financed by the government sector. Out of the 21 member countries for which data are available, 13 countries receive more than %50 of R&D funds from the government.
- In Kuwait, Nigeria, and Brunei, the share of government funding exceeds 90%.
- Despite having a share of less than 50%, government sector in Uganda is the dominant sector, providing more R&D funds than the other sectors.
- In Malaysia, government's share in R&D funding is as low as 2.4%, which is the lowest rate among all OIC countries with available data.
- Business Enterprise in Malaysia accounts for 84.5% of the total R&D funds. In Kazakhstan and Turkey, the business sector is also dominant, providing respectively 50.7% and 45.1% of the total R&D funds.
- Higher Education sector in Morocco provides 48.6% of the total R&D funds, which is the highest rate among all OIC countries for which data are available. Additionally, sector's share exceeds 10% in Turkey, Uganda, Kazakhstan, Burkina Faso, and Pakistan.
- Mozambique, Burkina Faso, and Mali deserve special attention as their R&D funds mostly come from abroad, 64.3%, 59.6%, and 49% respectively.

1.3 Patent Applications

Intellectual property rights, especially patents, are the key factors contributing to advances in innovation and scientific development. As a product of R&D activities, patents strengthen the link between science and technology, as the outcomes of research translate into new products or services. In this regard, although not all inventions are patented, the number of patent applications may be considered as a proxy for the degree of innovative capability in a country.

According to statistics from the World Intellectual Property Organization (WIPO), the total number of patent applications around the world in 2010 is estimated at 1.98 million. With a total of 33,379 patents, OIC member countries accounted for nearly 1.7% of total patent applications worldwide.

Meanwhile, 73.5% of global patents are filed by only 4 countries: USA (24.8% with 490,226 patents), China (19.8% with 391,177 patents), Japan (17.4 % with 344,598 patents), Republic of Korea (8.6% with 107,101 patents) and Germany (3.0% with 59,245 patents). To shed light on the situation in individual OIC member countries, Table 1.1 presents statistics on patent applications in countries for which data are available.

Table 1.1 Patent Applications by Office: Residents and Non-residents*

Country	Resident	Non Res.	Total	Year
Iran	5,970	557	6,527	2006
Malaysia	1,233	5,230	6,463	2010
Indonesia	516	5,122	5,638	2010
Turkey	3,180	177	3,357	2010
Egypt	605	1,625	2,230	2010
Kazakhstan	1,691	273	1,964	2010
Pakistan	114	980	1,094	2010
Morocco	152	882	1,034	2010
Saudi Arabia	288	643	931	2010
Algeria	76	730	806	2010
Uzbekistan	370	262	632	2010
Jordan	45	429	474	2010
Albania		361	361	2009
Bangladesh	66	276	342	2010
Tunisia	56	282	338	2005
Lebanon			316	2006
Azerbaijan	254	17	271	2010
Syria	133	133	266	2006
Kyrgyzstan	134	6	140	2010
Yemen	20	55	75	2010
Brunei		42	42	2009
Mozambique	18	22	40	2007
Sudan	3	13	16	2007
Tajikistan	7	3	10	2010
Uganda	6	1	7	2007
Bahrain			3	2003
Burkina Faso	2		2	2010

Source: World Intellectual Property Organization, Statistics on Patents, October 2012

* Patent application numbers for the most recent year with available data are considered. Most recent year with available data is indicated in the "Year" column. Numbers of patent applications for most African OIC countries are not provided individually as these countries are members of the African Regional Intellectual Property Organization (ARIPO). Total number of patents filed to ARIPO in 2009 is 448. Resident/non-resident breakdown is not provided for Bahrain and Lebanon.

In this respect, the following observations can be made to summarize the situation in the OIC countries:

- Patent activity is highest in Iran, Malaysia and Indonesia. In 2006, total patent applications (by residents and non-residents) amounted to 6,527 in Iran which is followed by Malaysia and Indonesia with patents reaching 6,463 and 5,638 in 2010, respectively.
- The number of patents is also above 1000 in Turkey (3,357), Egypt (2,230), Kazakhstan (1,964), Pakistan (1,094) and Morocco (1,034).
- In most of the OIC countries, applications by non-residents are higher than those filed by residents; where, in 11 of the 27 countries, with available data, non-residents applications account for more than 75% of the total applications. They are highest in Malaysia (5,230) and Indonesia (5,122), accounting for, respectively, 81% and 91% of the total patent applications.
- Applications by residents dominate only in 8 OIC countries, and they are the highest in Iran (5,970) and followed by Turkey (3,180).

1.4 Scientific Publications

Academic research is one of the most important components of research activities conducted in a country. To a certain extent, the performance in academic research can be well reflected by the number of scientific articles published in indexed journals. In this regard, the quantity and the growth of the research output; i.e., articles, are indicators commonly used to measure the research performance of a given institution or country. Indeed, such bibliometric indicators have been widely used in national science and technology statistics publications to measure scientific capacity and linkages to world science[3] and particularly in national and international rankings of universities[4].

OIC member countries as a whole published 92,503 articles[5] in 2011 in journals that are covered by Science Citation Index Expanded (SCI-EXPANDED), Social Science Citation Index (SSCI), and Arts & Humanities Citation Index (A&HCI), compared to 20,224 articles they published in 2000[6].

Although there is more than four-fold increase during the period under consideration, the amount reached is still below those of some individual countries in the world such as the United States and China. The published articles of Germany alone are also very close to the total publications of 57 OIC Member Countries (Figure 1.10).

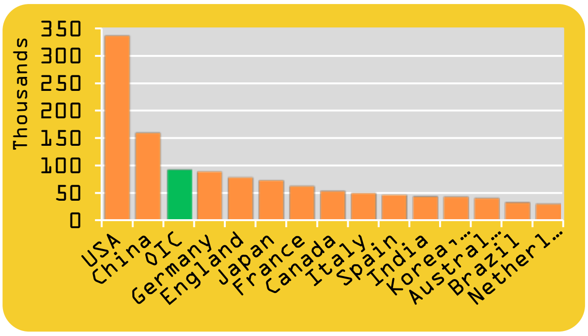
[3] UNESCO Institute for Statistics, "What do bibliometric indicators tell us about world scientific output?", *UIS Bulletin on Science and Technology Statistics*, Issue 2, September 2005.

[4] For example, *Academic Ranking of World Universities* by Shanghai Jiao Tong University (SJTU), *World University Rankings* by the Times Higher Education Supplement (THES), and also the *OIC University Ranking* make use of the research output as an important indicator in their ranking methodologies.

[5] The total reflects the sum of individual OIC countries and it is not refined for internationally co-authored papers.

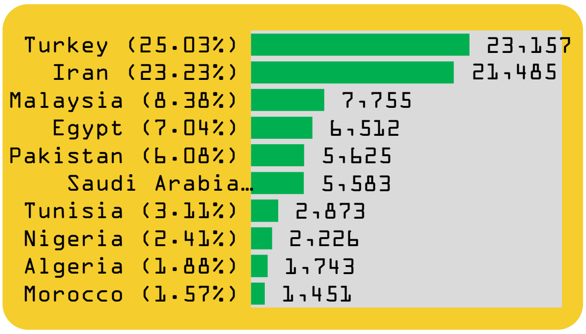
[6] Data are collected from the ISI Web of Knowledge maintained by Thomson Reuters. For further information, see *http://isiwebofknowledge.com/*

Figure 1.10 Number of Published Articles, 2011



Source: SESRIC staff calculations; ISI Web of Knowledge.

Figure 1.11 Top 10 OIC Countries by Published Articles, 2011



Source: SESRIC staff calculations; ISI Web of Knowledge.

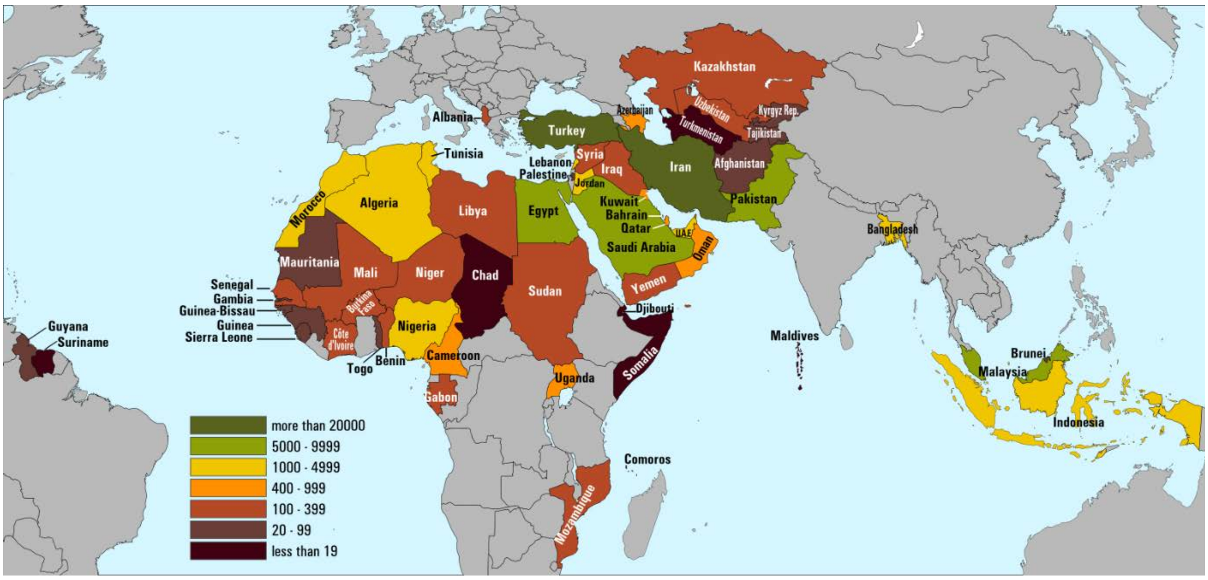
Figure 1.11 and Map 1.2 present information on the contribution of each OIC member country to total article publications in OIC countries. In this respect, the following observations outline the performance of the OIC member countries in publishing articles:

- Production of scientific publications –here articles– in the OIC member countries is heavily concentrated in a few of them.
- Nearly half of the total articles (48.26%) originate from only two member countries, Turkey (25.03%) and Iran (23.23%). Together with Malaysia (8.38%), Egypt (7.04%) and Pakistan (6.08%), these five countries alone account for 70% of all published articles (Figure 1.11).
- Some other member countries in the Middle East & North Africa, South Asia, and East Asia & Pacific also perform well while those in Latin America, Sub-Saharan Africa, and Central Asia are generally lagging behind.
- The number of countries having published less than 100 articles is 19.
- There are 7 countries that published less than 20 articles in 2011. These countries are not concentrated in one region but dispersed across regions: for example; from Suriname in Latin America to Somalia in Sub-Saharan Africa, and from Turkmenistan in Central Asia to Maldives in South Asia
- Nigeria stands out as the only Sub-Saharan member country to have produced over 1,000 articles (2,226), the closest ones in the region being Uganda and Cameroon with 692 and 586 articles, respectively.

1.4.1 The Evolution of Publication Outcome

The growth in the number of articles on a per-capita basis reflects a better indicator of productivity in scientific publications as it takes into account the relative size of the population in the countries

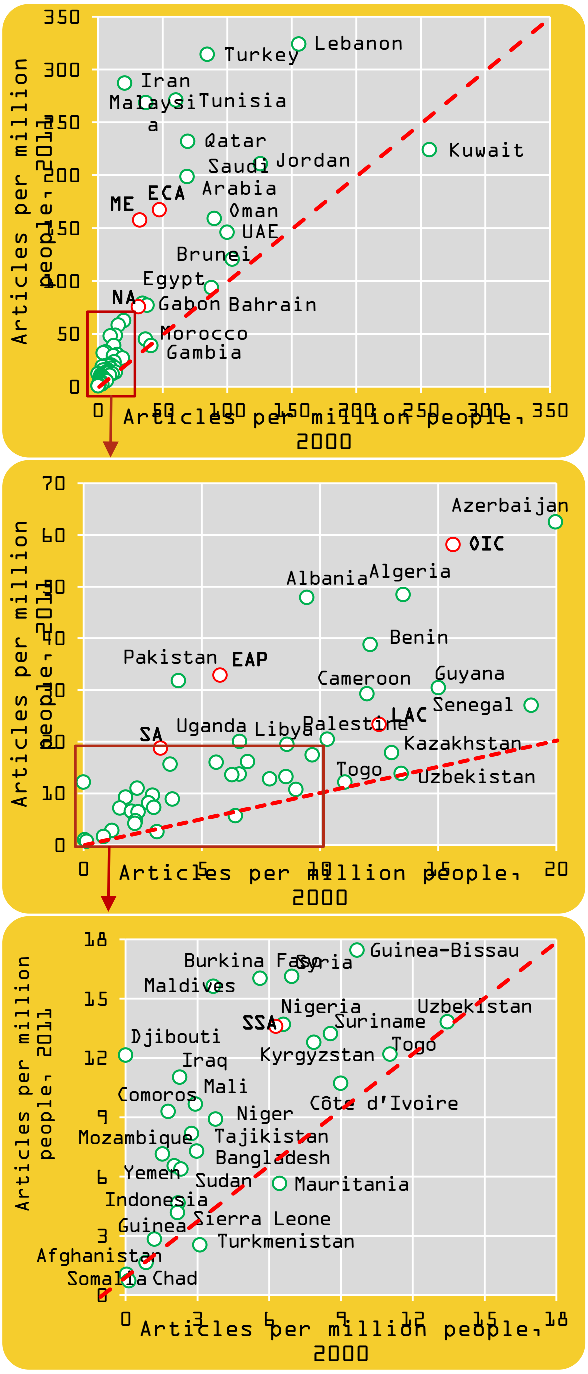
Map 1.2 Articles Published in International Journals, 2011*



Source: SESRIC staff calculations; ISI Web of Knowledge
***** Total number of articles published in journals covered by Science Citation Index Expanded (SCI-EXPANDED), Social Science Citation Index (SSCI), and Arts & Humanities Citation Index (A&HCI).

compared. In this respect, Figure 1.12 presents data on articles (pmp) in OIC countries in a manner to reflect the evolution in the period of 2000-2011. Accordingly:

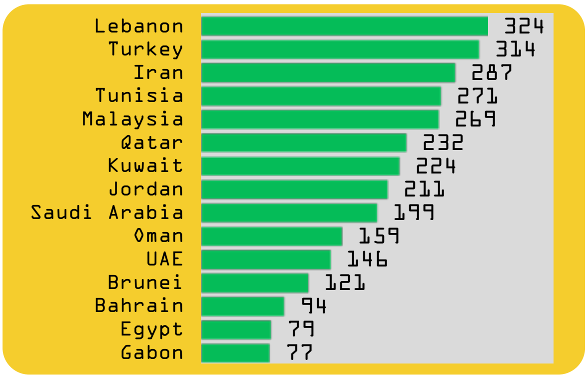
Figure 1.12 Articles per Million People: 2000 vs. 2011



Source: SESRIC staff calculations; ISI Web of Knowledge.
OIC Regional Averages [**ECA**: Europe & Central Asia, **NA**: North Africa, **EAP**: East Asia & the Pacific, SA: South Asia, **LAC**: Latin America and the Caribbean, **SSA**: Sub-Saharan Africa, **ME**: Middle East]

- On average, OIC member countries produced only 16 articles (pmp) in 2000 while this number increased to 58 in 2011, which could still be considered low given that this number reached up to 2972 in Switzerland, 1595 in Canada, 1091 in Germany, 1078 in USA, 919 in Republic of Korea, 586 in Japan, and 198 in Russia and 121 in China.
- 50 out of the 57 member countries recorded an increase in that period, but the increase in 24 of them was no more than 10 articles (pmp). This implies that the expansion recorded in countries with low number of articles (pmp) remained quite limited compared to those with high numbers.
- Iran, in absolute terms, took the lead in boosting scientific productivity with an increase of 267 articles (pmp), followed by Malaysia (232), Turkey (230), Tunisia (211), Lebanon (169), Qatar (163) and Saudi Arabia (130).
- Five other countries, namely Jordan, Oman, United Arab Emirates, Egypt and Azerbaijan recorded an increase of over 40 articles (pmp).
- 4 out of the 57 members, namely Kuwait, Gambia, Mauritania, and Turkmenistan, recorded a decrease in their articles (pmp). The highest decrease was reported in Kuwait (32 articles), while the decrease for the others was less than two articles. However, Kuwait still continues to rank in the 7th place with respect to articles per million people in 2011.
- Overall, according to 2011 data, there are only 16 members performing above the OIC average in terms of articles per million people. Lebanon, with 324 articles took the lead, and followed by Turkey (315), Iran (287), Tunisia (271), Malaysia (269), Qatar (232), Kuwait (224), and Jordan (211). Saudi Arabia, Oman, United Arab Emirates and Brunei also ranked at the top, having produced over 100 articles per million people. Bahrain, Egypt, and Gabon succeeded in entering the top 15 (see Figure 1.12 Top Panel and Figure 1.13).
- At the other side of the spectrum, there are member countries with even less than two articles (pmp), like Afghanistan, Chad, and Somalia.
- Most of the top ranked member countries are located in the Middle East. Articles (pmp) averaged at 158 in this region in 2011, compared to 32 in 2000.

Figure 1.13 Top 10 OIC Countries by Articles per Million People, 2011



Source: SESRIC staff calculations; ISI Web of Knowledge; UNESCO, UIS Data Centre.

- The average for the members in Europe & Central Asia increased from 47 to 167 in that period. Excluding Turkey, these averages fell down to 12 and 21, respectively.
- The averages for the other regions also increased in the period under consideration (North Africa: from 31 to 76; East Asia & Pacific: from 6 to 33; Latin America from 13 to 23, South Asia: from 3 to 19; and Sub-Saharan Africa: from 6 to 14).

2 SCIENCE AND TECHNOLOGY

2.1 Knowledge and Innovation

Higher education institutions and research and development (R&D) programs are the main forces in helping to attain economic growth and competitiveness for the knowledge-based societies. However, for most of the developing countries, the transition to the Knowledge Economy (KE) is not an easy goal to achieve. Knowledge Assessment Methodology (KAM) developed by World Bank is aimed to track overall preparedness of the countries towards knowledge based economy and to identify the challenges and opportunities they face in making this transition. For 2012, the KAM consists of 146 countries and 148 structural and qualitative variables measured on a normalized scale of 0 to 10.

Two of the widely used measures of KAM[7] tracking the performance of the countries are the Knowledge Economy Index (KEI) and Knowledge Index (KI). The KEI measures to what extent the environment is conducive for knowledge to be used effectively for economic development while KI measures a country's ability to generate, adopt, and diffuse knowledge. In terms of calculations, KEI involves four KE pillars: Economic and Institutional Regimes (EIRs), Innovation and Technological Adoption, Education and Training, Information and Communication Technologies (ICTs). On the other hand, KI is an aggregate index compiling the simple average of variables under the last three pillars. Hence, the KI does not take into account economic incentives and institutional regime.

Figure 2.1 depicts the positions of the top fifteen OIC member countries vis-à-vis the rest of the world in terms of their performance related to the KEI and KI. Depending on Figure 2.1, the following observations can be made:

- The KEI is above the world average of 4.44 in only 15 out of 41 OIC member countries for which the KEI is calculated. 10 of them also recorded above the average of upper middle income countries (4.76).
- UAE, Bahrain and Oman are the top three OIC member countries standing at 42nd, 43rd and 47th in the world, respectively.
- Including Malaysia (48th) and Saudi Arabia (50th) there are only five member countries in the top 50. However, 23 of the bottom 50 countries for which the KEI was calculated are OIC members.
- The average of OIC countries (2.97) is nearly one point lower than the average of non-OIC developing countries (3.95) and is even below the average of lower middle income countries (3.03).

The other widely used knowledge index, KI, measures a country's ability to generate, adopt, and diffuse knowledge. Based on Figure 2.1, the following observations can be deduced:

- The KI is above the world average of 4.53 in only 16 out of 41 OIC member countries for which the KI was calculated. But none of them managed to exceed the average of high income countries (8.47).

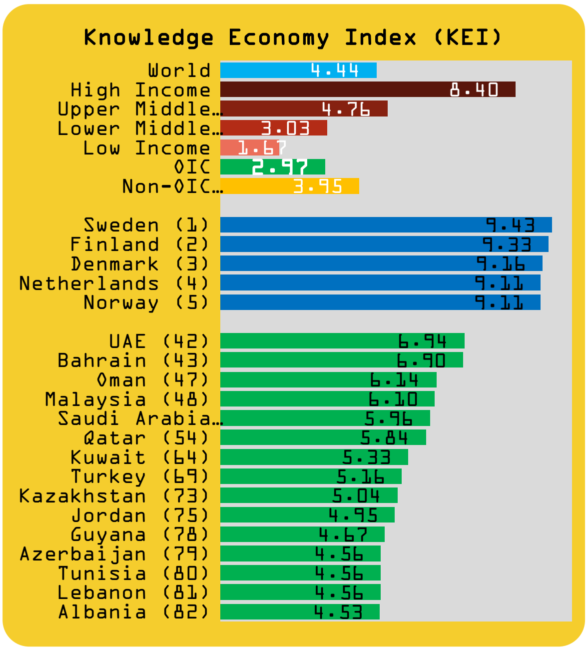
[7] http://siteresources.worldbank.org/INTUNIKAM/Resources/2012.pdf

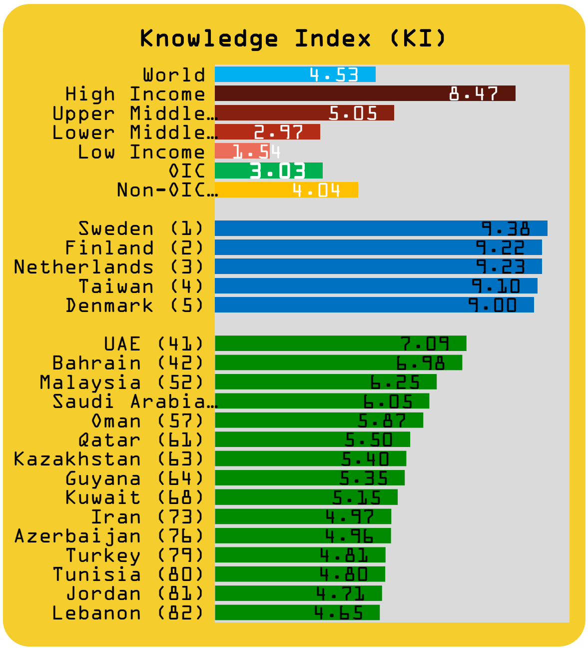
- UAE, Bahrain and Malaysia are the top three OIC member countries standing only at 41st, 42nd and 52nd, respectively.
- 22 of the bottom 50 countries for which the KI can be calculated are OIC members.
- The average of OIC countries (3.03) barely exceeds the average of lower middle income countries (2.97), but well below the average of upper middle income countries (5.05).

The OIC member countries perform slightly better when KI is used as opposed to KEI. This indicates that economic incentives (tariffs and non-tariff barriers) and institutional regime (rules and regulations) are two main reasons for OIC members' poor performance in knowledge and technology.

Innovation Index and Information and Communication Technology (ICT) Index, two components of the KEI and KI, are also important indicators on science and technology. In the rest of this section, these two indices are analysed for the

Figure 2.1 Knowledge Economy Index (KEI) and Knowledge Index (KI), 2012*

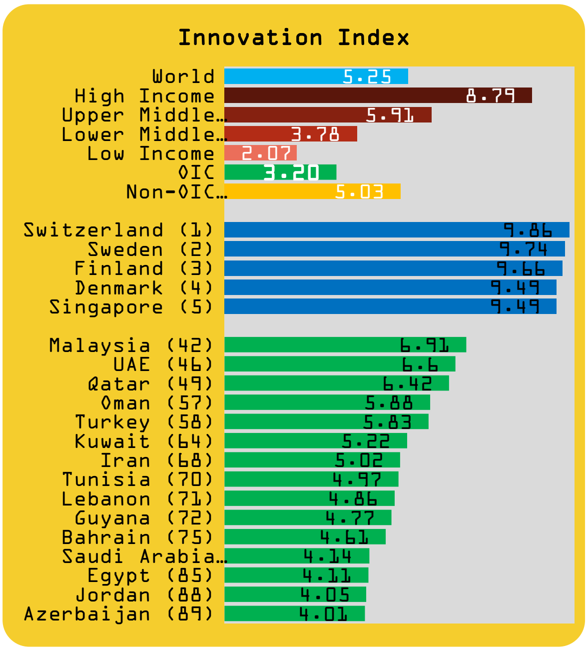


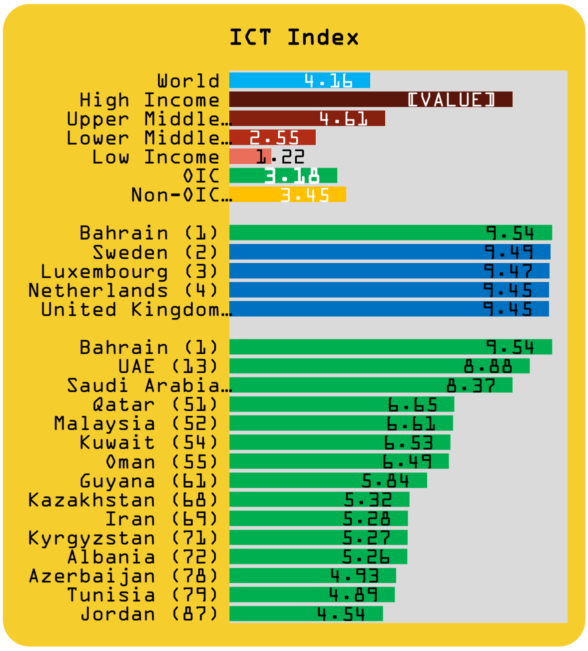


Source: SESRIC staff calculations; World Bank, KEI and KI Indices.

* KEI and KI are calculated for 146 countries and 41 OIC members. The index values for the world, OIC and other country groups are calculated by taking averages of index values for the relevant countries weighted by 2011 country populations. Numbers in parenthesis indicate the rank of the countries out of 145 countries.

Figure 2.2 Innovation and Information & Communication Technologies (ICT) Indices, 2012*





Source: SESRIC staff calculations; World Bank.

* Innovation and ICT indices are calculated for 146 countries and 41 OIC members. The index values for the world, OIC and other country groups are calculated by taking averages of index values for the relevant countries weighted by 2011 country populations. Numbers in parenthesis indicate the rank of the countries out of 146 countries.

OIC member countries. Innovation Index is the simple average of the normalized scores on three key variables: Total Royalty Payments and Receipts, Patent Applications Granted by the US Patent and Trademark Office, Scientific and Technical Journal Articles.

Figure 2.2 compares the OIC member countries with the rest of the world in terms of innovation and ICT. As seen in Figure 2.2 (top), the Innovation Index value is above the world average (5.25) in only 5 out of 41 OIC member countries for which the index was calculated. Malaysia, United Arab Emirates and Qatar are the top three OIC member countries standing at 42nd, 46th and 49th in the world, respectively.

ICT Index is the simple average of the normalized scores on three key variables: Telephone, Computer, and Internet Penetrations (per 1,000 people). As seen in Figure 2.2 (bottom), which compares the OIC member countries with the rest of the world with respect to the usage of telephone, computer, and the internet, ICT Index value is above the world average (4.16) in 16 out of 41 OIC member countries for which the index was calculated. With the ICTI score 9.54, Bahrain holds the top position among 146 countries. UAE (13th) and Saudi Arabia (21st) are also the other two OIC member countries where ICTI value exceeds the EU average.

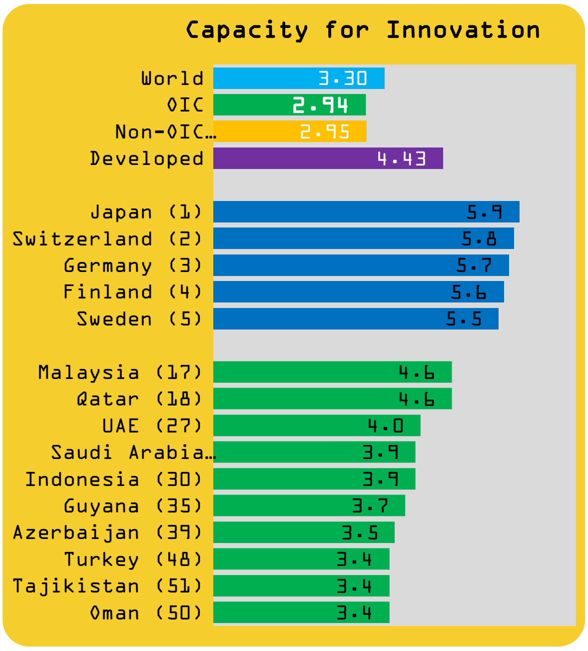
2.1.1 Capacity for Innovation and Global Innovation Index

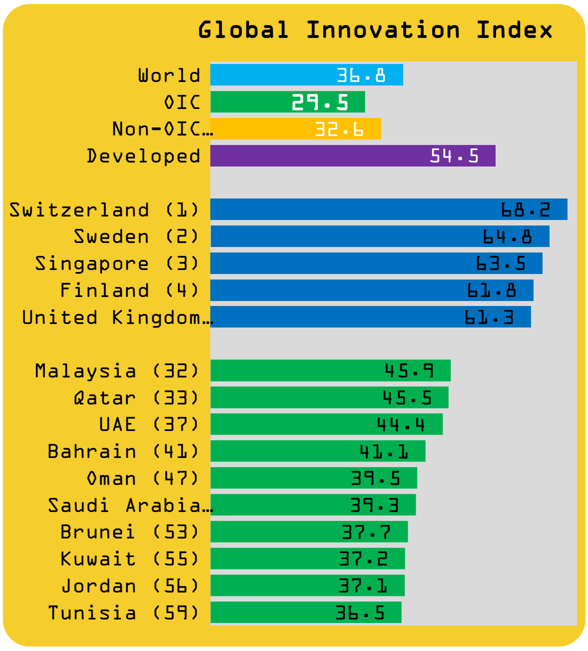
There are two additional indices comparing the innovative capacities of countries. The first index, called "Capacity for Innovation", measures the way the technology obtained by companies and it is published by World Economic Forum (WEF). By scaling the countries from 1 to 7, this index aims to gauge the overall capacity of countries for innovating new products and process. A country receives 1 if technology is obtained exclusively from licensing or imitating foreign companies and receives 7 if it is obtained by conducting formal research and pioneering their own new products and processes.

According to the latest data reported in World Competitiveness Report 2012-2013 of WEF, the average value of Capacity for Innovation in OIC countries was 2.94, which is below the world average (3.3) but nearly equal to the average of other developing countries (2.95). It is also well below the average of developed countries (4.43). As shown in Figure 2.3 (top), innovation capacity in only 10 OIC member countries is above the world average. Malaysia, Qatar, and UAE are the top three member countries (17th, 18th and 27th, respectively). Innovation capacity of Malaysia and Qatar exceeds the average of developed countries, as well.

The second index is called Global Innovation Index (GII) and prepared by INSEAD Business School and the World Intellectual Property Organization (WIPO). It is a composite indicator that ranks countries/economies in terms of their enabling environment to innovation and their innovation outputs. The 2012 version includes 141 economies, which represent 94.9% of the world's population and 99.4% of the world's GDP (in current US dollars). The GII is calculated as the average of two sub-indices: The Innovation Input Sub-Index gauges elements of the national economy which embodies innovative activities grouped in five pillars: (1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication, and (5) Business sophistication. The Innovation Output Sub-Index captures actual evidence of innovation results, divided in two pillars: (6) Knowledge and technology outputs and (7) Creative outputs.

Figure 2.3 Capacity for Innovation and Global Innovation Index, 2012*





Source: SESRIC staff calculations; World Economic Forum, Global Competitiveness Report 2012-2013; INSEAD Business School and WIPO.
* Capacity for Innovation is calculated for 144 countries and 41 OIC members while Global Innovation Index is calculated for 141 countries and 42 OIC members. The index values for the world, OIC and other country groups are calculated by taking simple averages of index values for the relevant countries. Numbers in parenthesis indicate the rank of the countries among the all included countries.

According to 2012 version of GII (Figure 2.3, bottom), the average value of index in OIC countries is 29.5, which is lower than the world average (36.8) and the average of other developing countries (32.6). It is also well below the average of developed countries (54.5). The best performer is Switzerland with an index value of 68.2 and the worst performer is Sudan with an index value of 16.8. Malaysia, Qatar, and UAE are the three best performing OIC member countries ranking 32nd, 33rd and 37th, respectively. On the other hand, 13 of 20 worst performers are OIC countries. Only 9 member countries have GII above the world average, but overall there is no OIC country above the average of developed countries.

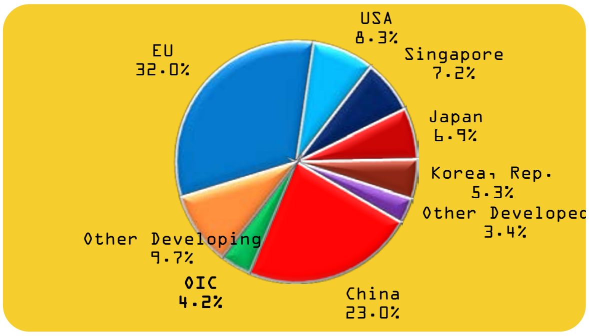
These two indices indicate that OIC countries, on average, are lagging behind in terms of their innovativeness. Therefore, they need to enhance their innovative capacities and improve their enabling environment for innovating new products and processes. This will ensure long term sustainable growth and help them to increase their competitiveness *vis à vis* other countries.

2.2 High Technology Exports

High-technology exports (HTE) are products with high R&D intensity, including aerospace, computers, software and related services, consumer electronics, semiconductors, pharmaceuticals, scientific instruments and electrical machinery, which mostly depend on an advanced technological infrastructure and inward FDI in high-tech industries.

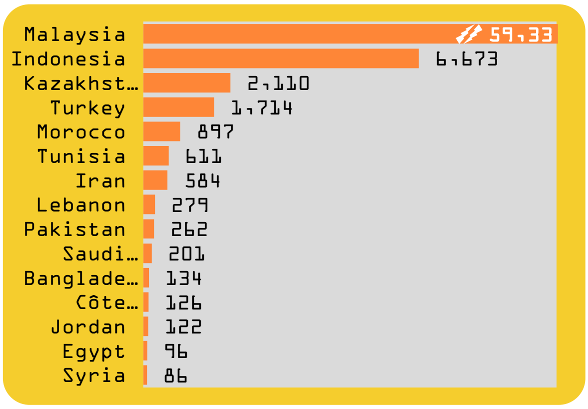
World high-technology exports are estimated to be around $1.7 trillion in 2010, slightly increasing from its $1.5 trillion level in 2009, but it is still lower than the 2008 level of $1.8 trillion. Around 63.1% of that amount originated from developed countries, of which 32% from the EU members, 8.3% from the United States, 7.2% from Singapore, 6.9% from Japan,

Figure 2.4 HTE, % of World Total 2010



Source: SESRIC staff calculations; World Bank, WDI Online.

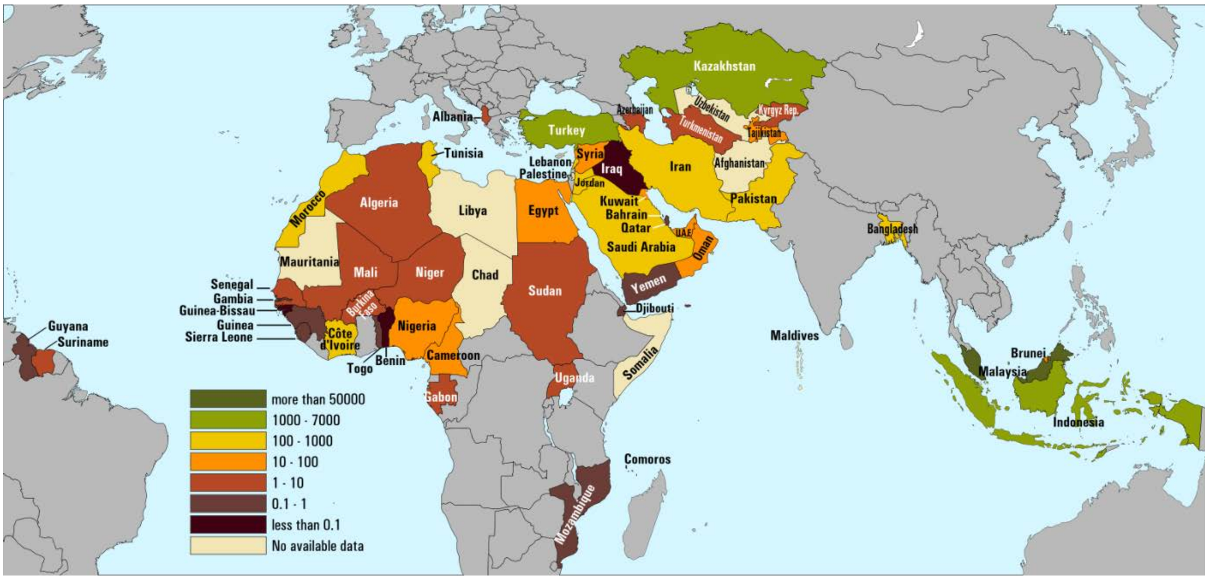
Figure 2.5 Top 15 OIC Member Countries (HTE Million $), 2010



Source: SESRIC staff calculations; World Bank, WDI Online.

5.3% from Korea Republic and 3.4% from other developed countries (Figure 2.4). With $406 billion exports of high technology products, China is the largest exporter of HTE, accounting for 23% of the world total and 62.4% of the total HTE of developing countries. Confirming the lack of adequate infrastructure and FDI in most of OIC countries, it is

Map 2.1 High Technology Exports (Million US$)*



Source: SESRIC staff calculations; World Bank, WDI Online
***** Data for 2010 or latest available year.

observed that all the member countries for which the data are available accounted for only 4.2% of the world total HTE of $1.7 trillion (Figure 2.4), or 11.3% of the total HTE of developing countries.

Data for OIC countries are illustrated in Figure 2.5 and Map 2.1, which yield the following observations:

- With more than $59 billion, Malaysia accounts for nearly 81% of the total HTE of the OIC in 2010. It is also the 10^{th} largest exporter of high-technology products in the world, accounting for 3.2% of the world HTE.
- Indonesia, Kazakhstan and Turkey follow the lead Malaysia with $6.7 billion, $2.1 billion and $1.7 billion, respectively. Except these 4 countries, none of the OIC countries exceeded the threshold of $1 billion.
- Morocco ($897 million), Tunisia ($611 million) and Iran ($584 million) have HTE above half a billion, whereas Lebanon, Pakistan, Saudi Arabia, Bangladesh, Côte d'Ivoire and Jordan recorded HTE figures varying between $122 million (Jordan) and $279 million (Lebanon).
- Among these countries, it should be mentioned that Cote d'Ivoire, with $126 million of HTE, gets far ahead of the other Sub-Saharan members. It is also ranked as the 9th largest exporter of high-technology products in the OIC.
- On the other hand, HTE of the other leading member countries are below $100 million. At the bottom end, Benin and Iraq recorded HTE figures around $50,000 while Guinea-Bissau and Comoro have HTEs even less than $5,000.

2.3 Nanotechnology

Nanotechnology is the study of manipulating matter on an atomic and molecular scale. It deals with developing materials, devices, or other structures possessing at least one dimension sized from 1 nanometre (one millionth of a millimetre) to 100 nanometres.

Nanotechnology is very diverse which gives humanity the opportunity to directly control matter on the atomic scale. Nanotechnology entails the application of fields of science as diverse as surface science, organic chemistry, molecular biology, semiconductor physics, micro-fabrication, etc. Nanotechnology also offers fascinating possibilities and solutions including producing many new materials and devices with a vast range of applications in medicine, electronics, biomaterials and energy production.

Although the OIC Member Countries are taking individual steps in this field, there is still a synergic potential to manage, develop and re-allocate available resources to excel in nanotechnology by enhancing cooperation and collaboration among the OIC member countries.

The following are recommended as ways and means for enhancing the networking among nanotechnology centres in the OIC Member Countries:

1. Establishing a world-class nanotechnology centre: In order to raise future nanoscientists for catering the human resources need of the OIC Member Countries in nanotechnology, a world-class nanotechnology centre should be established. Besides offering graduate nanotechnology programs, this Centre should also host an intellectual property and incubation office providing venture capital support to nanotechnology start-up companies.
2. Exchange of nanoscientists for long term between the existing nanocentres: For period ranging from 12 months to 24 months, an exchange of nanoscientists should take place between the existing nanocentres for targeted research areas. This exchange program should also give financial support to nanoscientists regarding salary, research grants, and equipment usage fees.
3. Support programs for individual nanoscientists to use existing nanocentres for short term: Similar to the long-term exchange program, under this scheme students working towards for a doctoral degree in nanotechnology or researchers should be given the opportunity to use existing nanocentres for a period of one or two weeks. This program should also financially support the nanoscientists regarding their travel, accommodation, and fees for nanocentre usage.
4. Collaborative nanotechnology research projects: With the support of high technology firms, at least three OIC Member Countries should collaborate for targeted research areas in nanotechnology. The European Union's Seventh Framework Programme offers a sample model for such collaborative research projects.
5. An annual nanotechnology conference and project fair: In order to increase networking and collaboration opportunities among the researchers and investors of the OIC Member Countries, an annual nanotechnology conference and project fair should be organised. On the sidelines of this conference, a project fair and a researcher-investor business forum would also enhance

the interaction among the OIC Member Countries.

6. Experience sharing between the existing nanocentres for training nanocentre technicians: By organising 4 to 6-week study visits, the technicians working at nanocentres should be trained under workshops focusing on specific techniques.

3 POLICY RECOMMENDATIONS

The primary finding of this detailed analysis on the current stance of S&T in OIC member countries is twofold. First, major indicators on research and scientific development display a large disparity within the OIC member countries. Second, the OIC members, individually or as a group, lag far behind the rest of the world, particularly the developed countries, with a few exceptions. In line with the main findings of this analysis, some broad policy recommendations will be presented in this section.

While the availability of researchers varies considerably across the OIC member countries, most of these countries lag behind the world, with inadequate quantity of researchers employed in R&D activities. However, the OIC average for women researchers as a percentage of total researchers is slightly higher than the average of EU, and many individual OIC countries have higher shares than even the average for the EU member countries. On the other hand, spending on the research and development is significantly low in the OIC Countries. The low R&D intensity introduces major challenges for OIC member countries, as only eight member countries are spending more than 1% of GDP on R&D in comparison to the world average of 2.2%. While some countries have recorded significant increases in their R&D intensity in the last ten years, most of them reported stable expenditures on R&D. Although the OIC Ten-Year Programme of Action called upon the member countries to encourage R&D programmes and ensure their individual R&D intensity is not inferior to half of the world average, the OIC countries are still far away from this target and, with the current trends, it seems difficult to meet the Programme target on time. Therefore, there is a dire need for more efforts to be exerted in this area in order to close the gap with the rest of the world. To achieve this, R&D should be stimulated through government and private sector initiatives and coordination among the OIC member countries.

As another important indicator on research and scientific development, production of scientific articles is concentrated in a few of the OIC members. In 2011, the OIC member countries produced around 92,500 articles, 70% of which originated in only five countries, namely Turkey, Iran, Malaysia, Egypt and Pakistan. Moreover, the number of articles was less than 100 in 19 OIC member countries. From 2000 to 2011, the number of articles per million people, on average, increased by 42 articles to reach 58, which is still low given that in some countries it exceeds 1,000. To close the gap with the rest of the world and among the members, higher education and academic research should be supported rigorously by the governments. The establishment of universities and research centres through funds and financial incentives should be encouraged. OIC member countries should improve living standards for scientists to reduce brain drain from member countries to other countries and to lead brilliant minds to academic work. The participation of women in university education should be improved through the elimination of the obstacles that prevent them from attending higher education. Academic research should be promoted through research grants and lesser teaching loads.

In this connection, intra-OIC networking opportunities could be facilitated through projects, similar to the Framework Programmes of the European Union, to support research and technological development in the Islamic world and to promote joint research initiatives among the member countries. Additionally, joint ventures among companies in OIC member countries in research intensive sectors should be encouraged towards more effective and cost efficient R&D investments. OIC countries may also take advantage of R&D spill-overs by rapidly learning about new technologies developed in other countries and improving them, and by importing technological goods and services from their high-tech trade partners.

Referring to the available data on 27 OIC member countries, the present report finds that patent applications are below the world average and mostly filed by non-residents, implying that indigenous innovation capability in most of these countries is at low levels. The OIC member countries have no choice but to adopt measures to encourage patenting and technology licensing. In particular, an initiative can be put in place to educate small and medium-sized enterprises about the benefits and regulations of the patent system. Additionally, an OIC level patent system, similar to African Regional Intellectual Property Organization or European Patent Organisation, can be developed to increase incentives for patent application in the Islamic world. Such a system not only brings higher benefits for patent holders through the right of being granted patents in a larger geography, but also will foster the establishment of relationships between the members in matters relating to R&D and patents, and promote exchange of ideas, research, and studies on industrial property matters.

As a result of the low R&D intensity coupled with inadequate technological infrastructure, high technology exports of the OIC member countries are quite limited, accounting for only 4.2% of the world high technology exports in 2010. Malaysia, with HTE of $59 billion in 2010, is the largest exporter of high-technology products among the OIC member countries. Indonesia, Kazakhstan and Turkey, each with HTE figures above $1 billion, exhibit good prospects for further increase in their HTEs. In this context there is a dire need to increase the share of high technology products in the exports of manufactured goods of the OIC member countries.

An important component of scientific development is the infrastructure of internet and other information and communication technologies. This is particularly important in the OIC member countries, which have a high density of youth population. First of all, telecommunication sectors should be liberalized for better products and services in the OIC member countries. Some countries such as Saudi Arabia and Turkey successfully liberalized their telecommunication sectors in the last two decades. However, there is a strong need to speed up the privatization and liberalization of telecommunication sectors in many other OIC member countries. Governments should also promote internet usage through tax reductions on internet services and transferring internet subscription charges from consumers to telecom sector and internet service providers. To meet human resource needs in information and technology related sectors, it is important to encourage technology related majors in higher education.

Finally, OIC Member Countries need to adapt to the very dynamic global market place in a timely manner, and take their part in the new phase of scientific development. As nanotechnology is envisioned by many scientists and researchers as the next major advancement in science and technology, it is very critical that special attention is given to this important area by the governments, science community and the private sector through public-private partnerships and OIC-wide networking. SESRIC has been raising awareness on this important topic in the Islamic world. The global market for nanotechnology products is estimated to reach $1 trillion by 2015. OIC member countries are at a cross road to be major players of this advancement. It is imperative that joint research and investment on nanotechnology is initiated among the OIC countries as the pioneers of this new technology will benefit enormously from their early investment in this area.

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