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TECHNOLOGY ACHIEVEMENT INDEX OF MUSLIM NATIONS – RANKING AND COMPARATIVE STUDY

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Abstract

This study examines the technology progress of Muslim nations, in terms of technology achievement index-2013 (TAI-13 OIC). TAI is comprised of four main components i.e. technology creation, diffusion of old technologies, diffusion of new technologies and development of human skills. A ranking of 34 Muslim countries, including ranking in each sub-dimension of the index, is presented. Comparative analysis of TAI ranking of 22 countries, common to the present and previous studies of 2011 under similar conditions, is also presented which shows useful information about the shift in technological situation of these countries over a period of 5 years. To investigate the technological spread the standard deviation approach has been used. The comparison of different indices, such as GCI, HDI, and GDP per capita with TAI-13 OIC has been reported for the first time. At the end of article, policy guidelines have been suggested for S&T policy makers and planners of the Muslim countries.

Keywords: Technological achievement index, Diffusion of technology, Human skill development, Creation of technology.

Introduction

The technological progress is the continuous process of improvement in total scientific knowledge, skill, applied science, and the technical efficiency / ability to convert the existing factor of production into more output, available to any human society for industry, art, science etc. In other words, technological progress tells about the entire process of invention, innovation and diffusion of technology all over the industry or society (Wikipedia, 2013). Achievement in technology is the key for economic development of a country. Cobb Douglas production function (CDPF) is the most commonly used Production Function (PF) in Economics. CDPF is the function of factor inputs used to produce given level of output; inputs comprise labour, capital, land and technology level, for the measurement of efficiency. Two Americans, namely, Charles Cobb (a mathematician) and Paul Douglas (an economist), who introduced the CDPF, interpreted output as the function of total productivity or an index of technology, capital stock index, labour index, keeping capital as a constant factor. Technology changes are assumed to be exogenous. Changes in the factors of production are independent, and neutral technical progress effect is further assumed on the given factors of production (Cobb and Douglas, 1928). Another applied economist highlighted that the term "technical progress" may be used in three different ways: (i) the effect of technology changes or the role of technical change in the growth process more specifically; (ii) explanation of technical improvement factors; (iii) the changes in technology itself. Improvements in research, invention and development innovation lead to enhancement in design, performance of plants and machinery which results in increased economic activities (Wall, 2006).

From the above discussion, it is clear that the development in almost all advanced areas such as transportation, telecommunication, material resources and pharmaceuticals etc., is based on science and technology. We can say that the science and technology are omnipresent and universal in toady's world. Technical progress plays a vital role in the development of any country. Therefore, technology progress always remains a matter of interest for S&T planners, policy makers and economists. Policy makers in developing countries rely heavily on basic statistics of S&T to adapt their science, technology and innovation (STI) policies. Such statistics do give distinct individual pictures of different relevant aspects of STI, but fail to provide broader picture of strengths, weaknesses and opportunities, on national level. For example, statistics of national research and development (R&D) expenditure, number of R&D institutes and university enrollment in science and engineering give clear picture in these areas of national STI system but, individually, they are unable to explain the strengths, efficiency and their impact on the national STI system comprehensively.

In order to get a more meaningful and complete STI picture at national and global level, basic statistics of S&T output indicators are selected and

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combined in this study. The indices so developed are known as composite STI indicators and are primarily used to provide awareness about weaknesses, strengths and opportunities on national level. Some of these indicators are used to rank different countries taking into consideration different aspects of science, technology and innovation. Policy makers use composite S&T indicators to formulate policy measures and approaches to augment countrywide competences in order to compete with other nations in a global framework. However, there are several constraints in using composite S&T indicators especially for developing countries, where markets and STI systems are not efficient as the STI data is not collected rigorously and aggregation processes are generally not reliable. The ranking of countries, in such cases, may consequently be misleading.

Literature Review

A bird eye view of some well-known studies regarding STI composite indicators is being presented below:

Technology index was part of the growth competitiveness index (GCI), reported by World Economic Forum (WEF) in 2001. This index gives a composite picture of a country's innovative, technology transfer, information and telecommunication level. Wagner et al. (2002) proposed science and technology capacity index-2002 (STCI-02) for the RAND Corporation. STCI-02 measures the degree to which a state can take up and utilise scientific and hi-tech knowledge in comparison with other countries. Technology achievement index (TAI) was first introduced by Desai et al. in 2002. TAI spotlights on evaluating technological performance of a country-capacity based on generating and utilising technology but has not been used for measuring countries' technological development. Michael Porter and Scott Stern (2003) developed national innovative capacity index (NICI), which gives an idea of country's potential, both as a political and economic unit, to produce a torrent of commercially relevant innovations. Industrial development scoreboard was developed by UNIDO in 2003 and reported in industrial development report (IDR) in 2004. It is based on technological activity, competitive industrial performance, ICT infrastructure and technology imports. It signifies the industrial performance of a country (UNIDO, 2003; UNIDO, 2004; Lall and Albaladejo, 2003). European innovation scoreboard (EIS) and its summary innovation index (SI) is the product of the European Commission (2004). The innovative performance of European Union (EU) member states is evaluated and compared by EIS. Archibugi and Coco (2004) developed the new indicator of Technological Capabilities (ArCO). The main reason of developing this indicator was to provide the technological capabilities measurement both for developed and developing countries. Industrial-cum-technological advancement (ITA) index was developed by UNIDO and published in its Industrial Development Report 2005 (UNIDO, 2005). ITA is a structural index aiming to capture core characteristics of an economy focusing on the role of industry and technology and their interactions. ITA comprises four indicators for industrial development based on performance. These are: (i) share of manufacturing in GDP, (ii) share of manufacture in total export, (iii) share of medium-or-high technology activities in manufacturing value added (MVA), and (iv) share of medium/high technology activities in total export. High technology indicator (HTI) was developed by Alan Porter and David Roessner at the Georgia Institute of Technology and was later revised by Porter et al. (2005). Since the last adjustment, HTI is now composed of 4 input indicators, a composite input indicator and an output indicator. The input indicators include national orientation, socio-economic infrastructure, technological infrastructure and productive capacity.

It is viewed that out of all the indices mentioned earlier, the most appropriate one, based on technology achievement for any country on a comparative scale, may be the technology achievement index (TAI). Technology Achievement Index-2002 (TAI-02) focused on assessing a country's technological performance based on its capability in creating and using technology but not on overall size of its technological development. It is for this reason that a small country like Finland is higher in TAI ranking than USA, UK and Germany etc. TAI-02 study shows ranking of 72 countries according to their TAI values. The index focuses on outcomes and achievements rather than on effort or inputs such as number of scientists, R&D expenditures, or policy environments. This is because the causal relationship between these inputs and outcomes are not well known. For example, do more scientists lead to more technological advancement output? Do countries that spend more on R&D achieve more? The TAI is not a measure of a country which is leading in global technology development, but focuses on how well is it participating in creating and using technology (Desai et al., 2002). The TAI focuses on assessing the technological performance of a country based on its capability in creating and using technology but NOT on the overall size of its technological development (Nasir et al., 2011).

Nasir et al. (2011) have extended and developed TAI-09, in which they examined the existing technological capabilities and capacities of 91 countries. It discusses different policy options for the countries characterized in the study as potential leaders, dynamic adopters and marginalised countries. The study has also examined overall and different dimensions of technology achievement of a group of 56 countries, which are common in the

TAI-02 and TAI-09 studies, and presented some interesting findings. They proposed the standard deviation approach for the technological spread in their study.

Almost all the indices developed so far discuss the progress/development of developed countries (i.e., OECD member countries, European Union). Only a few studies are available regarding the developing countries (Perhaps due to non-availability of data of developing countries). No specific study has been made about the Muslim countries. In the present study, for the first time, TAI has been developed for the Muslim nations, based on dynamic characteristics, e.g. economic activities, geography and level of development, etc.

The Islamic world consists of 57 independent states that spread from Turkey to Togo and from Indonesia to Algeria whereas it has a share of more than 25% of the total world population. 60% of the world's crude oil is produced by Muslim countries, which in terms of trade, amounts to about 70% of the world crude oil. The share in total world production in jute, palm oil, natural rubber, natural gas, grain, cotton and sugar is 80%, 75%, 70%, 37%, 25%, 13% and 10%, respectively (see Fig. 1). Although, Muslim countries in Africa are rich in natural resources and minerals, like, aluminum, copper, tin, lead, zinc and phosphate, but they are not able to materialise these natural resource for economic development because they are lagging behind in the transmission of technological capability (ISESCO, 2009).

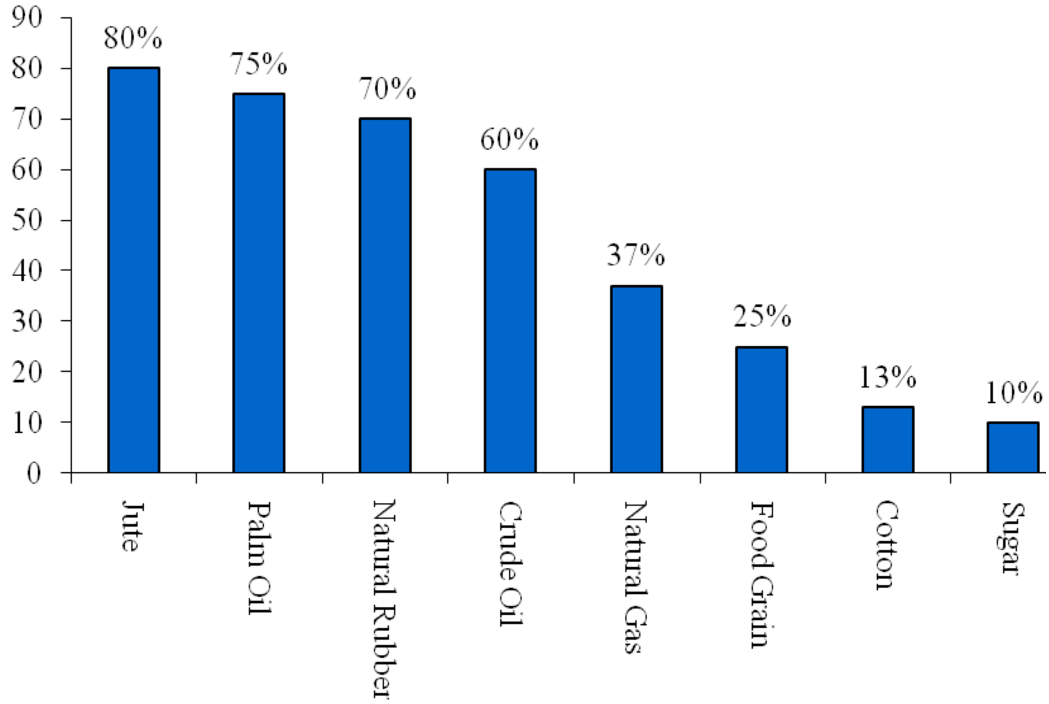

Fig. 1. Production of raw material in the Muslim countries.

Source: (ISESCO, 2009)

United Nations categorises least developed countries on the basis of low gross domestic product (GDP), weak human capital and under-developed economies. In 1971, the list of least developed countries (LDC) comprising only 8 OIC countries while in 2008, this figure increased to 22, by addition of 14 more OIC countries which were categorized as LDCs in 1997-2001 (Naim, 2010; ISESCO, 2008).

On the basis of scientific and industrial development, ISESCO (2009) in its report divided Islamic Countries into the following three broad categories:

i. Countries with significant scientific and industrial base: viz. Azerbaijan, Egypt, Indonesia, Iran, Jordan, Kazakhstan, Kuwait, Malaysia, Turkey, Uzbekistan.

ii. Countries in which a fair scientific and industrial base exists: viz. Algeria, Bahrain, Bangladesh, Kyrgyzstan, Lebanon, Libya, Morocco, Nigeria, Oman, Pakistan**,** Qatar, Senegal, Sudan, Syria, Saudi Arabia, Tunisia, United Arab Emirates, Uganda, Yemen.

iii. Countries with hardly any scientific and industrial base: viz. Afghanistan, Albania, Benin, Brunei Darussalam, Burkina Fasso, Cameroons, Chad, Comoros, Cote D'Ivoire, Djibouti, Gabon, Gambia, Guinea, Guinea Bissau, Guyana, Iraq, Maldives, Mali, Mauritania, Mozambique, Niger, Sierra Leone, Somalia, Surinam, Tajikistan, Togo, Turkmenistan.

Tanveer and Atta-ur-Rahman (2009) have classified 57 member states of the Organization of Islamic Conference (OIC) in three categories:

i. Scientifically developing countries (SDCs)

ii. Scientifically aspiring countries (SACs)

iii. Scientifically lagging countries (SLCs)

ISESCO classification depicts that 27 (about half) Islamic countries lie in the third category of countries with hardly any scientific and industrial base while 19 and 10 are placed in second and first category, respectively. Thirty four (34) Muslim countries out of 57 have been placed in the third category of SLCs while 14 and 9 are in SACs and SDCs, respectively (Naim and Atta-ur-Rahman, 2009. It indicates that scientific and technological development in Islamic countries is very sluggish.

Present paper may be considered as a continuation of our earlier study (Nasir et al., 2011) and is an attempt to identify the key policy and scientific and technological gaps in OIC countries which are responsible for their present state of low social and economic development. The contrasting development strategies of OIC and East Asian countries and some selected innovation indicators are compared to draw policy lessons.

Materials and Methods

Data: Data about all the eight indicators was not available for all 57 Muslim countries, therefore, 34 countries for which data was available have been included in the study. For collection of data, various data sources like databases of different organizations such as Islamic Scientific Educational and Cultural Organizations (ISESCO), Statistical Economic and Social Research Training Center for Islamic Countries (SESRIC) were utilised. The data mostly covering the social and economic sectors was obtained from these databases. All sources of information that have been used in the current study are reliable and trustable worldwide. The data for different indicators falling under different TAI dimensions have mostly been taken from reliable internet sources as given in Table 1.

Composition of index: The index comprises four dimensions that collectively enlighten the technological achievement of a country, which indicates the readiness and ability of the country to participate in the network age.

Table 1. Data variables and their sources.

Dimension	Indicators	Sources
Creation of technology	**Patents granted to residents (per million people):**	**World Intellectual Property Organization (WIPO), 2011**
	Receipts of royalties and license fees (US$ per person)	**World Bank (World Development Indicators), 2012**
Diffusion of recent innovations	**Internet users (per 1000 people)**	**World Bank (World Development Indicators), 2012**
	High-technology exports (%age of manufactured exports)	**World Bank (World Development Indicators), 2012**
Diffusion of old innovations	**Electric power consumption (kWh per capita):**	**World Bank (World Development Indicators), 2012**
	Telephone mainlines + Cellular subscribers a (per 1,000 people)	**World Bank (World Development Indicators), 2012**
Human skills	**Gross enrollment ratio. All levels combined (except pre-primary)**	**Database of UNESCO Institutes of Statistics, 2012**
	Gross enrollment ratio in science, engineering, manufacturing and construction at Tertiary level	**Database of UNESCO Institutes of Statistics, 2012**

Each dimension is composed of two sub-indicators that are directly linked with objectives of technology policy regardless the level of development of a country. Detailed description about these dimensions has already been described in the earlier studies by Desai et al. (2002) and Nasir et al. (2011). But for the sake of ease of readers a brief description of four dimensions and their corresponding sub-indicators are reproduced here (Table 2).

Methodology: Technology achievement index-2013 for OIC (TAI-2013 OIC) has been calculated using goalposts (Table 3) following the same methodology presented in technical note in TAI-02 (Desai et al., 2002) and TAI-09 (Nasir et al., 2011) under similar conditions. Equal weightage has been assigned to all four dimensions and their sub-indicators and their average has been taken for calculation of scores. Ranking and index value of the Technology Achievement Index-2013 for OIC has been presented in Table 4.

Table 2. Four dimensions and their sub-indicators.

Dimension	Sub-indicators
Creation of technology	Patents granted to residents (per million people): Stock of embedded knowledge. An indirect indicator of knowledge that has been developed and could be polished for future use. It also reflects the current level of creative activity.
	Receipts of royalties and license fee (US$ / person): The indicator reveals the stock of successful innovations already done, but is worth uses in future.
Diffusion of recent innovations	Internet users (per 1000 people): dispersion of internet is pre-requisite for participation in the world economic activities. One of the most active and dominant tools to access the global information at relatively low cost.
	High-technology exports (%age of manufactured exports): The indicator is the best yardstick for measuring the annual average growth rates (AAG_R) in the country where they have high technology.
Diffusion of old technologies	Electric power consumption (kWh/capita): The indicator gives a reasonably precise initiative about the diffusion of electricity within a society. (The closest proxy used is consumption of electricity). The indicator is important because of its use in new technologies and also for the accumulation of other human activities.
	Telephone mainlines + Cellular subscribers (per 1000 people): This indicator shows the participation of the people in the communication upheaval. Countries must adopt this old innovation to participate successfully in the present IT network era.
Human skills development	Gross enrollment ratio all levels (except pre-primary): Although the mean year of schooling was used as a proxy for cognitive skill, however, due to non-availability of relevant data, the present work uses 'Gross Enrollment Ratio GER' as a proxy for the measurement of cognitive skills.
	Gross enrollment ratio in science, engineering, manufacturing and construction (Tertiary): This indicator evaluates the skills of a nation in construction, engineering, mathematics and science at the tertiary level.

Table 3. Goalposts for calculating the TAI-13 OIC for 34 countries.

Sr. No.	Name of indicator	Observed maximum value	Observed minimum value
1.	Patents granted to residents per million people (2000-2010)	57.72	0.00
2.	Receipts of royalty and license fees in US$ per 1000 people (2006-2010)	62203.93	0.00
3.	Internet users per 1000 people (2007-2010)	780.00	10.0
4.	High-technology exports (% of manufactured exports) (2006-2010)	62.20	0.00
5.	Telephone (mainlines and cellular) per 1000 people (2010)	2030.00	80.0
6.	Electricity consumption, KWH per capita (2009)	17610.00	0.00
7.	Gross enrollment ratio, all levels combined (except pre-primary)(2006-2011)	89.60	0.00
8.	Gross enrollment ratio in science, engineering, manufacturing and construction. Tertiary (2006-2011)	18.40	0.00

Results and Discussion

The study intended to develop technology achievement index (TAI) for all 57 member countries of OIC, however, it was only possible for 34 countries for which data of essential indicators of gross enrollment ratio (GER) and GER in science in the dimension of human skill development (which is a major element for growth for any country) were available (Table 4). For remaining countries, data were not available or missing for one or more essential indicators, due to which TAI-13 OIC could not be calculated for these countries.

The results are very interesting and disappointing too in terms of technology progress of Muslim countries. In previous studies, the countries were grouped into leaders, potential leaders, dynamic adopters and marginalised countries. In the current study, 34 countries have been classified into four groups as: (i) Very Efficient (TAI > 0.500), (ii) Active (0.350 ≤ TAI ≤ 0.499), (iii) Passive (0.200 ≤ TAI ≤ 0.340), and (iv) Fragile (TAI<0.200), on the basis of TAI value ranging from 0.674 for Malaysia and 0.018 for Djibouti. Most of the countries have nil or very low value for patents and royalties which indicate that little formal innovation has occurred in those countries.

Very Efficient (TAI > 0.500): There are only five countries in this group with Malaysia at the top, followed by Iran, UAE, Bahrain and Saudi Arabia. This group is considered to be very efficient in human skills, diffusion of old and recent innovations but low in technology creation. All countries in this group are oil rich countries. Malaysia which is at the top in exporting high technology manufactured goods which is 45% of its manufactured exports. Iran, UAE, Bahrain and Saudi Arabia (oil rich countries) are spending heavily on education (4.7% (2009), 1.2% (2008), 2.9% (2008) and 5.6% (2008), respectively as compare to other Muslim countries (CIA, 2011) and also have high electricity consumption per capita. These countries are considered to be very efficient and stand as top 5 Muslim nations.

Active (0.350 ≤ TAI ≤ 0.499): Fourteen countries fall in this category. Eight out of these are oil producing countries including Lebanon, Brunei, Jordan, Oman, Tunisia, Qatar, Azerbaijan, Albania and Algeria. Lebanon is at the top of this group while Tajikistan lies at the bottom. Most of the countries in this group have high level of human skills and have diffused old innovations very well. However, they are lagging behind in technology creation. Among them, Lebanon and Brunei are performing very well in human development skills and diffusion of old innovations in spite of the zero value in technology creation standing and are at the 6th and 7th position, respectively. Bahrain and Brunei Darussalam are spending heavily on education and have high electricity consumption per capita. They fall in this group mainly due to these two factors.

Passive (TAI = 0.200 – 0.340): Six countries are included in this group including Uzbekistan, Suriname, Iraq, Pakistan, Cameroon and Nigeria. Although, these countries are passive in the use of diffusion of recent innovations and zero index in technology creation but their level of human skills is relatively better. Pakistan is the 6th largest nation in the world and 2nd largest nation among the Muslim countries by population and the only atomic power in Muslim countries but its performance in human skills development, technology creation and diffusion is very low. Small percentage of GDP (< 0.2% as set by World Bank in MDGs) is allocated for education out of the total budget. Pakistan is facing energy crisis also due to little investment in this sector in order to fulfill the energy requirements of people. These may be the major constraints for knowledge based economic growth and participation in the knowledge based economy, and therefore, it has been placed at 23rd position in the list of 36 Muslim countries.

Fragile (TAI < 0.200): This group consists of nine countries with Bangladesh at the top and Djibouti at the bottom. All countries in this group are observed to be very week in each dimension, especially, in diffusion of old inventions. These countries require high investment in education sector in order to improve human skills and also need greater attention for the diffusion of old technologies.

Comparison of 22 Muslim countries common to TAI-13 OIC and TAI-09 studies: Twenty two (22) Muslim countries were selected which were common in both TAI- 09 and TAI-13 OIC for comparison. To make it logical and meaningful, the results of 22 common countries of TAI-09 have been re-ranked on the basis of TAI value calculated by Nasir et al. (2011) (Table 5).

The comparison shows some interesting results. Countries' TAI ranking reveals that top six countries, including, Malaysia, Iran, UAE, Bahrain, Lebanon and Bahrain, in 2009, retain their position in 2013 with slight change. The shift in TAI ranking position of Iran, Oman, Guyana and Tajikistan are highly significant while there is a little shift in the overall ranking position of other countries. Malaysia retains its position at the top while Iran jumps from 6th position to 2nd position. Among 22 common countries, four countries retain their positions and eleven countries move upward while seven countries move down in their ranking.

Table 4. Technology Achievement Index 2013 for OIC (TAI-13 OIC) with corresponding sub-Indices and their rankings.

			Technology Creation (TC)				Diffusion of Recent Innovations (DRI)				Diffusion of Old Innovations (DOI)				Development of Human Skills (DHS)			
Country Name	Technology Achievement Index 2012	Overall Ranking TAI -12	Patents granted to residents (per million people) (2000-2010)	Receipts of royalties and licence fees (US$ per person) (2006-2010)	TC index	TC ranking	Internet users (per 1000 people) (2007-2010)	High-technology exports (% of manufactured exports) (2006-2010)	DRI index	DRI ranking	Telephone mainlines + Cellular subscribers a (per 1,000 people) (2010)	Electric power consumption (kWh per capita) (2009)	DOI index	DOI ranking	Gross enrolment ratio. All levels combined (except pre-primary). Total (2006-2011)	Gross enrolment ratio in science, engineering, manufacturing and construction. Tertiary (2006-2011)	DHS index	DHS ranking
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Very Efficient (TAI >0.5)																		
Malaysia	**0.674**	1	7.183	9.507	**0.139**	5	550.000	45.000	**0.851**	1	1370	3614	**0.943**	7	71.330	15.219	**0.765**	3
Iran (Islamic Republic of)	**0.592**	2	57.720	-	**0.500**	1	130.000	4.000	**0.122**	19	1270	2238	**0.897**	9	70.940	18.395	**0.848**	1
United Arab Emirates	**0.502**	3	3.942	-	**0.034**	7	780.000	3.000	**0.533**	2	1650	11464	**1.000**	1	67.158	4.795	**0.442**	14
Bahrain	**0.502**	4	-	-	**0.000**	27	550.000	0.000	**0.351**	7	1420	9214	**1.000**	3	87.20	5.767	**0.656**	7
Saudi Arabia	**0.5**	5	-	-	**0.000**	28	410.000	1.000	**0.271**	14	2030	7427	**0.988**	4	84.340	9.914	**0.742**	4
Active (TAI = 0.35 - 0.499)																		
Lebanon	**0.494**	6	-	1.684	**0.014**	11	310.000	13.000	**0.339**	8	890	3130	**0.822**	14	81.398	13.137	**0.803**	2
Brunei Darussalam	**0.486**	7	-	-	**0.000**	29	500.000	6.000	**0.385**	6	1290	8662	**0.975**	5	83.057	4.520	**0.584**	10
Jordan	**0.476**	8	1.984	-	**0.017**	10	390.000	3.000	**0.280**	12	1170	2112	**0.872**	10	79.452	11.278	**0.734**	5
Oman	**0.469**	9		-	**0.000**	30	630.000	1.000	**0.414**	4	1760	5724	**0.974**	6	75.410	3.736	**0.491**	13
Tunisia	**0.459**	10	5.651	2.351	**0.068**	6	370.000	5.000	**0.289**	11	1170	1311	**0.846**	13	77.969	8.102	**0.633**	8
Qatar	**0.44**	11	0.692	-	**0.006**	13	690.000		**0.442**	3	1490	14421	**1.000**	2	57.423	3.372	**0.312**	24
Turkey	**0.44**	12	-	-	**0.000**	31	400.000	2.000	**0.275**	13	1070	2298	**0.853**	12	75.610	8.773	**0.629**	9
Kyrgyzstan	**0.435**	13	19.757	0.204	**0.173**	4	140.000	1.000	**0.096**	22	1000	1402	**0.808**	15	76.035	9.912	**0.664**	6
Azerbaijan	**0.433**	14	22.366	0.016	**0.194**	3	370.000	1.000	**0.245**	15	1180	1621	**0.860**	11	69.726	3.619	**0.434**	15
Albania	**0.397**	15	-	0.231	**0.002**	15	450.000	1.000	**0.297**	10	1520	1747	**0.909**	8	67.936	2.243	**0.380**	19
Morocco	**0.391**	16	0.156	0.120	**0.002**	14	490.000	8.000	**0.401**	5	1120	756	**0.804**	16	60.393	3.975	**0.356**	21
Guyana	**0.368**	17	-	62.204	**0.500**	2	300.000	0.000	**0.188**	16	940	-	**0.395**	27	69.198	2.176	**0.390**	17
Algeria	**0.362**	18	2.366	0.057	**0.021**	9	130.000	1.000	**0.089**	23	1000	971	**0.788**	18	78.051	5.000	**0.550**	11
Tajikistan	**0.352**	19	-	0.093	**0.001**	19	120.000	-	**0.071**	27	910	1985	**0.802**	17	71.755	6.577	**0.534**	12

Contd…

Table 4. Concld…

			Technology Creation (TC)				**Diffusion of Recent Innovations (DRI)**				**Diffusion of Old Innovations (DOI)**				**Development of Human Skills (DHS)**			
Country Name	**Technology Achievement Index 2012**	**Overall Ranking TAI -12**	**Patents granted to residents (per million people) (2000-2010)**	**Receipts of royalties and licence fees (US$ per person) (2006-2010)**	**TC index**	**TC ranking**	**Internet users (per 1000 people) (2007-2010)**	**High-technology exports (% of manufactured exports) (2006-2010)**	**DRI index**	**DRI ranking**	**Telephone mainlines + Cellular subscribers a (per 1,000 people) (2010)**	**Electric power consumption (kWh per capita) (2009)**	**DOI index**	**DOI ranking**	**Gross enrolment ratio. All levels combined (except pre-primary). Total (2006-2011)**	**Gross enrolment ratio in science, engineering, manufacturing and construction. Tertiary (2006-2011)**	**DHS index**	**DHS ranking**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Passive (TAI = 0.200 - 0.34)																		
Uzbekistan	**0.321**	20	-	-	**0.000**	32	190.000		**0.117**	20	810	1636	**0.761**	19	70.749	2.282	**0.407**	16
Suriname	**0.311**	21	1.298	1.334	**0.022**	8	320.000	12.000	**0.335**	9	1920		**0.500**	25	68.847	2.240	**0.388**	18
Iraq	**0.279**	22		0.007	**0.000**	24	20.000	0.000	**0.006**	32	800	1069	**0.735**	20	62.678	3.903	**0.376**	20
Pakistan	**0.243**	23	0.066	0.017	**0.001**	20	170.000	2.000	**0.126**	18	610	449	**0.616**	21	43.708	5.000	**0.228**	27
Cameroon	**0.229**	24	-	0.016	**0.000**	21	40.000	5.000	**0.075**	26	450	271	**0.508**	24	63.536	2.023	**0.333**	23
Nigeria	**0.228**	25	-	-	**0.000**	33	280.000	1.000	**0.186**	17	560	121	**0.521**	22	55.848	0.021	**0.206**	29
Fragile (TAI < 0.200)																		
Bangladesh	**0.191**	26	0.141	0.004	**0.001**	17	40.000	1.000	**0.031**	30	470	252	**0.515**	23	52.150	1.764	**0.219**	28
Mozambique	**0.18**	27	0.825	0.001	**0.007**	12	40.000	1.000	**0.031**	31	310	453	**0.437**	26	58.873	0.347	**0.243**	26
Uganda	**0.15**	28	-	0.116	**0.001**	18	130.000	2.000	**0.100**	21	390	-	**0.163**	30	68.541	0.371	**0.335**	22
Guinea	**0.104**	29	-	0.010	**0.000**	23	10.000	0.000	**0.000**	33	400	-	**0.170**	29	52.277	2.711	**0.246**	25
Mali	**0.102**	30	-	0.015	**0.000**	22	30.000	2.000	**0.035**	29	490	-	**0.224**	28	48.273	0.580	**0.150**	30
Burkina Faso	**0.072**	31	-	0.001	**0.000**	25	10.000	8.000	**0.089**	24	360	-	**0.142**	31	38.541	0.503	**0.057**	32
Sierra Leone	**0.063**	32	-	0.217	**0.002**	16	10.000	-	**0.000**	34	340	-	**0.127**	32	46.735	0.166	**0.125**	31
Niger	**0.035**	33	-	0.000	**0.000**	26	10.000	7.000	**0.078**	25	260	-	**0.056**	33	33.870	0.182	**0.004**	34
Djibouti	**0.018**	34			**0.000**	34	70.000	0.000	**0.039**	28	210	-	**0.000**	34	34.263	1.046	**0.032**	33

Table 5. Comparison of 22 countries common to TAI-09 and TAI-13 OIC.

Sr. No.	Name of country	TAI – 13 OIC	Ranking TAI -13 OIC	TAI - 09	Ranking TAI -09	Category
1.	Malaysia	0.674	1	0.490	1	PL
2.	Iran	0.592	2	0.325	6	DA
3.	UAE	0.502	3	0.387	2	PL
4.	Bahrain	0.502	4	0.383	3	PL
5.	Lebanon	0.494	5	0.341	5	DA
6.	Brunei	0.486	6	0.375	4	PL
7.	Jordan	0.476	7	0.319	8	DA
8.	Oman	0.469	8	0.297	12	DA
9.	Tunisia	0.459	9	0.313	10	DA
10.	Turkey	0.44	10	0.312	11	DA
11.	Kyrgyzstan	0.435	11	0.296	13	DA
12.	Albania	0.397	12	0.268	15	DA
13.	Morocco	0.391	13	0.263	16	DA
14.	Guyana	0.368	14	0.321	7	DA
15.	Algeria	0.362	15	0.274	14	DA
16.	Tajikistan	0.352	16	0.317	9	DA
17.	Uzbekistan	0.321	17	0.244	17	DA
18.	Pakistan	0.243	18	0.168	20	M
19.	Cameroon	0.229	19	0.173	19	M
20.	Nigeria	0.228	20	0.167	21	M
21.	Bangladesh	0.191	21	0.147	22	M
22.	Mozambique	0.180	22	0.179	18	M

PL: Potential leader, DA: Dynamic adopter, M: Marginalised.

Table 6 shows the summary statistics of TAI-09 and TAI-13 OIC of 22 Muslim countries. It clearly indicates 34.7% decline in TAI-13 for OIC countries during 2009-2013. It reveals that Muslim nations are trying to reduce S&T capability gap over this period rapidly which is a positive sign.

Table 6. Summary of statistics of technology achievement index (TAI) of 22 Muslim countries.

Year/Data	TAI-13 OIC	TAI-09
Sum	6.361	8.792
Mean	0.289	0.400
Variance	0.007	0.016
Standard deviation	0.083	0.127
Percent change	-34.65	

Growth, development and technology progress in Muslim countries: Three indices have been selected in Table 7. GDP per capita is considered to be the yard stick for the measurement of economic development or stability. Human development index (HDI) is a tool developed by the United Nations to measure and rank countries' level of social and economic development while global competitiveness index (GCI) compares countries' productivity and efficiency and highlights their comparative advantages and advisability of investing in them. The index examines the efficiency of different sectors of national economies and their contributions to a country's productivity. It is useful for countries as it identifies the strengths and weaknesses of their economies. These indices give measure of economic growth, development and efficiency of a country.

Although this cross sectional data does not show long-run relationship between GDP and technology progress, however, different growth theories show that the relationship exists between development and technology. Table 7 shows that the Muslim countries which have high value of GDP also have high value in these indices and *vice versa*. There are only four Islamic countries: UAE, Brunei, Qatar, Bahrain (out of 57), which lie in the group of very high human development (ranging from 0.943 to 0.793) out of 188 countries. In the group of high human development (ranging from 0.783 to 0.698), only 12 Muslim countries have been placed. 15 Muslim countries are included in the medium human development group (ranging from 0.698 to 0.522), while 24 Muslim countries are listed in low human development category (ranging from 0.510 to 0.286). In case of GCI only three Muslim countries Qatar, Saudi Arabia and Malaysia have value of GCI greater than 5.00, out of 142 countries. There are only 13 Muslim countries that have a value above 4.00 for GCI and 21 Muslim countries have value above 3.00.

Table 7. Overview of gross domestic product of Muslim countries and their placement in different indices.

S. No.	Name of country	GDP per capita (current US$)-2011	Global competitiveness index (GCI) 2011-2012	Human development index (HDI) 2011	Technology achievement index 2009	Technology achievement index 2013 for 34 Muslim countries
1.	Qatar	89736	5.243	0.831	-	0.440
2.	Kuwait	51497	5.021	0.760	-	-
3.	Brunei	40244	4.779	0.838	0.375	0.486
4.	UAE	39058	4.891	0.846	0.387	0.502
5.	Saudi Arabia	24116	5.168	0.770	-	0.500
6.	Oman	23133	4.639	0.705	0.297	0.469
7.	Bahrain	22467	4.536	0.806	-	0.502
8.	Gabon	11789	-	0.674	-	-
9.	Kazakhstan	11259	4.185	0.745	-	0.435
10.	Turkey	10605	-	0.699	0.312	0.440
11.	Malaysia	10012	5.084	0.761	0.490	0.674
12.	Lebanon	9148	3.946	0.739	0.341	0.494
13.	Suriname	8125	3.674	0.680	-	0.311
14.	Azerbaijan	7190	4.314	0.700	0.383	0.433
15.	Iran	6816	4.257	0.707	0.325	0.592
16.	Maldives	6488	-	0.661	-	-
17.	Iraq	5687	-	0.573	-	0.279
18.	Turkmenistan	5495	-	0.686	-	-
19.	Algeria	5258	3.958	0.698	0.274	0.362
20.	Jordan	4666	4.187	0.698	0.319	0.476
21.	Tunisia	4350	4.281	0.698	0.313	0.459
22.	Albania	4109	4.064	0.739	0.268	0.397
23.	Indonesia	3472	4.377	0.617	-	-
24.	Guyana	3258	3.730	0.633	0.321	0.368
25.	Morocco	3044	4.165	0.582	0.263	0.391
26.	Egypt, Arab Rep	2972	3.879	0.644	-	-
27.	Uzbekistan	1545	-	0.641	0.244	0.321
28.	Sudan	1539	-	0.408	-	-
29.	Nigeria	1486	-	0.459	0.167	0.228
30.	Yemen, Rep.	1361	3.058	0.462	-	-
31.	Cote d'Ivoire	1242	3.372	0.400	-	-
32.	Cameroon	1197	3.607	0.482	0.173	0.229
33.	Pakistan	1196	3.579	0.504	0.168	0.243
34.	Mauritania	1154	3.201	0.453	-	-
35.	Kyrgyz Republic	1124	3.447	0.615	0.296	-
36.	Senegal	1084	3.697	0.459	-	-
37.	Chad	876	2.870	0.328	-	-
38.	Comoros	872	-	0.433	-	-
39.	Tajikistan	835	-	0.607	0.317	0.352
40.	Benin	746	3.777	0.427	-	-
41.	Mali	739	3.387	0.359	-	0.102
42.	Bangladesh	732	3.731	0.500	0.147	0.191
43.	Burkina Faso	650	3.253	0.331	-	0.072
44.	Afghanistan	620	-	0.398	-	-
45.	Guinea-Bissau	596	-	0.353	-	-
46.	Togo	569	-	0.435	-	-
47.	Gambia, The	518	3.842	0.420	-	-
48.	Mozambique	511	3.311	0.322	0.179	0.180
49.	Sierra Leone	501	-	0.336	-	0.063
50.	Uganda	479	3.559	0.446	-	0.150
51.	Guinea	457	-	0.344	-	0.104
52.	Niger	364	3.446	0.295	-	0.035

Sources. World Bank Database, UNDP-HDR-2011, WEF-GCR-2011.

Of the 72 countries, only 11 countries were included in TAI ranking as reported by Desai et al. in 2000. Among them only Malaysia was placed in category of potential leader at 30th position out of 72 countries, while 6 were placed in dynamic adopter category and 4 in marginalised category. After a decade, a study done by Nasir et al. (2011) under similar conditions, only 22 Muslim countries were included in this study, among them there were only four countries, which could be seen in potential leader category i.e. Malaysia, United Arab Emirates, Bahrain, and Brunei Darussalam, while 13 courtiers were placed in Dynamic Adopter and 5 in marginalised category.

In the present study, only five countries have been included in very efficient (TAI > 0.5) group which are Malaysia, Iran, UAE, Bahrain, Saudi Arabia and 14 countries have been included in Active (TAI = 0.350 - 0.499) category, 6 in Passive (TAI = 0.200 - 0.340) and 9 countries were placed in Fragile (TAI < 0.200) group.

These facts indicate that the quality of life, economic growth, development and efficiency of different sectors of the national economies and their contributions to the countries' productivity are poor in most of the Muslim countries. The details given above show that the Muslim countries, like, Malaysia, Iran, Saudi Arabia, United Arab Emirates, Qatar, Bahrain and Brunei Darussalam are scientifically and technologically better, based on these indices. The Muslim countries will have to voyage long journey to improve their ranking based on these indices. Therefore, a long-term planning is required for economic development, growth through the process of proper application of science and technology, which may improve the quality of life of the people living in Islamic countries.

Limitation of the Study: Although the index is not a full coverage of all Muslim countries but this is close to a realistic picture of technological capacity of the Muslim nations. The data considered most appropriate and trustworthy for the assessment of technology have been employed in the study. The data for gross enrollment ratio (GER) and GER in science is not available for 23 Muslim countries. Therefore, we have to limit the study to 34 countries. The data of patent and royalty payments is either missing or undervalued for some of the countries. For calculation purpose in these cases, the zero value has been used.

Policy Recommendations for Muslim Countries

TAI informs about the level of achievement, strengths and weaknesses with regard to the technological readiness of a country. Some policy recommendations for selected countries i.e. Malaysia, Iran, UAE, Qatar, and Pakistan are given below:

Malaysia: Malaysia has a population of about 29 million and is placed at 58th position in the world. Its GDP per capita is 10,012 US dollar (2011) and its health and education expenditures are 8% (2009), 4.1% (2009) of GDP, respectively (CIA, 2011). Malaysia is at the top in TAI-13 OIC of the Muslim countries and is one of the few developing countries which are progressing rapidly in technological innovation and has high achievement in technology creation, diffusion and development of human skills. Among Muslim countries, it is also at the peak in high-technology exports (45% of manufactured exports) and receipts of royalties and license fees (9.5 US$ per person). High index of Malaysia is due to its success in diffusion of recent innovations and development of human skills. The country has successfully achieved most of the MDGs or is on the tack of attaining these goals and targets (UN, 2010). Although, in terms of MDGs, socio-economic indicators of Malaysia are positive, but to become a fully developed nation, there are still some challenges in terms of science and technology that are required to be addressed. To meet these challenges the country has to work in its weak areas, like, health, technology diffusion (for spreading electricity, telephone), human resource development, higher education and skill training. Its expenditure on research and development is only 0.63% (2005) compared to the expenditure on R&D of Korea which is 4.2% of its GDP (2009) (CIA, 2011). It also needs to improve university education as well.

Iran: Iran is the 7th largest country in the Muslim world by population and 4th by oil producing countries in the world and has GDP per capita of 6,816 US dollar (2011). Its health and education expenditures are 4.7% (2009) and 3.9% (2009), respectively (CIA, 2011). While the country is already on a track to meet many of MDGs, yet it has a long way to go to reduce disparities between the rich and the poor, the young and the old, men and women as well as inhabitants of different regions (UN, 2006). Iran's performance is very impressive as compared to other Muslim countries, except Malaysia, in terms of TAI 13 OIC. It ranks at 2nd position out of 34 Muslim countries and has been placed in very efficient category. Iran is on the top among all Muslim countries in technology creation and development of human skills, however, it is behind in diffusion of recent and old innovations. Electric power consumption (kWh per capita) and telephone (per 1000 people) is low in Iran compared to UAE and even Qatar. This indicates that these basic facilities still have not reached to the entire population of Iran. These technologies are very essential for the development of newer technologies and also play a key role in the betterment of human life. In diffusion of recent innovations (internet user and high tech exports), Iran is also very behind other Muslim countries, like, Pakistan, Malaysia, Qatar etc. These indicators show that Iran has to do a lot of work for developing its technology capacity. The gross enrollment ratio (all level combined) is 70% that is less in contrast to Bahrain (87%), and Saudi Arabia (84%). This raises the question, is the education system of Iran fully coped to meet the new challenges of technological preparedness? Iran spends less on R&D (0.79% of its GDP) than Korea and Israel (3.74%, 2009 and 4.40%, 2009, respectively) (CIA, 2011). The statistics shows that

Iran has to increase the R&D budget to enhance research and development.

United Arab Emirates (UAE): UAE is one of the few dynamic countries in Arab region that is having a high GDP per capita (39,058 US dollar, 2011) after Qatar and Kuwait. Regarding MDGs, this country has a great potential and strong governmental will which is seen to achieve the targets set in MDGs by 2015 (UNDP, 2007). UAE has been able to meet the majority of the goals, and is continuing to meet the remaining goals and their targets. UAE is ranked at 3rd position out of 34 countries with the index value 0.502 and is placed in very efficient category. UAE is ranked at the top and second in diffusion of old and recent innovations, respectively, among the Muslim world while it is behind in technology creation and human skill development. For example, gross enrollment ratio in Iran is 67% as compared to 87%, 78% and 69% in Bahrain, Algeria and Suriname, respectively. Similarly, gross enrollment ratio in science, engineering, manufacturing and construction at tertiary level is only 4.8% which is far less than 18.4% and 13.13% in Iran and Lebanon, respectively. Leading developing countries, like, Korea and Malaysia have acquired quick progress in technological achievement because they have invested more on education and health, while UAE spends only 1.2% (2009) of its GDP on education far less than 4.7% (2009), 4.1% (2008) of Iran and Malaysia, respectively (CIA, 2011). UAE is very low in technology creation. The number of patents granted per million population is only 3.9 per million population as compared to other countries, like, Turkey (12) and Jordan (8). However, technological progress/advancement is growing better than ever before. Basic education is essential to get accustomed to the new technologies constantly. We cannot be certain that UAE education system can fully cope with new technological advancement. It needs to be improved to meet the challenges of 21st century.

Qatar: Qatar has the highest per capita income (89,736 US dollar, 2011) not only in all Muslim countries but also in the entire World. The performance of the country is very impressive in the diffusion of old and recent innovations as it is on the top in terms of electricity consumption among Muslim countries and is leading in the use of internet than many other Muslim countries, like, Malaysia, Iran and Bahrain. Although, oil and natural gas revenue has enabled Qatar to provide the basic facilities to its inhabitants, but is far behind in human skill development and technology creation than other Muslim countries like Lebanon, Jordon, Tunisia. Gross enrollment ratio is 57.4% in Qatar that is behind many other Muslim countries that are placed in passive and fragile category, like, Uzbekistan (70.7%) and Uganda (68.5%). Its gross enrollment ratio in science, engineering, manufacturing and construction at tertiary level is 3.73% which is lower than 9.9% and 5% for Kyrgyzstan and Algeria. Number of patents granted to residents per million populations in Qatar is 0.692 which reflects that the technology creation and innovation capability of the country is very low as compared to other countries of the region, like, UAE, Jordan, etc. In spite of that Qatar is the richest country in the world. Its expenditure on education and R&D is 3.3% (2005) and 0.3% (2006) as the percentage of GDP which is less compared to Malaysia and Iran (CIA, 2011). The country requires to invest more on education and R&D to improve human skill level and technology capacity, so that its habitants can be able to use the advance technologies that are being created in the worldwide effectively and efficiently.

Pakistan: Pakistan has the sixth largest population (184 million) in the world and had GDP per capita of US D$1,196 in 2011. Pakistan spends only 2% and 0.9% of its GDP (CIA, 2011), on education & health and is ranked the lowest in South Asia for per budget allocation on health and education. Pakistan is on a track for only two millennium development goals (MDGs) out of eight whereas as its progress is off track for 6 MDGs (UNDP, 2012). It has made enough progress in nuclear technology and capability and has become first atomic power in Muslim countries. However, in spite of getting the status of nuclear power, Pakistan is still legging behind in human skill development and technology creation and stands at 27th and 20th position out of 34 Muslim countries in development of human skill and technology creation, respectively. The country is behind number of other Muslim countries, like, Iran, Turkey and Malaysia. Pakistan is also far behind in terms of gross enrollment ratio (43.7%) than Malaysia, Bahrain and Lebanon which have 87.2%, 81.4%, and 71.3%, respectively. Similarly, its gross enrollment ratio in science, engineering, manufacturing and construction at tertiary level is only 5% whereas for countries in "very efficient" category like Iran, Malaysia and Lebanon, it is 18.39%, 15.21% and 13.13%, respectively.

Though, Pakistan has substantial capacity in the sate of the art technology, innovation, but TAI-13 value indicates that these technological advances are not prevalent. Pakistan still has 610 telephone mainlines + cellular subscribers per 1,000 people as compared to 2030, 1650 and 1370, for Saudi Arabia, UAE and Malaysia, respectively. Pakistan is facing a serious energy crisis these days in both electricity and CNG sector which are considered not only the backbone of industrial sector development but also very essential for diffusion of technology that has not been pervasive. That is the reason the first class competence to innovate has not been translated into patents or royalties and license earnings to any significant level.

Conclusions

Although, TAI-13 OIC does not reflect how technological achievement transform into the human developments yet, it gives indication about the technological achievement / technological readiness of a country to participate in global knowledge based economy. On the basis of above empirical analysis and discussion, the following policy guidelines are suggested for all Muslim countries.

The index provides very valuable and interesting information to the policy makers/ planners to device the S&T policy for a country. On the basis of the above facts and figures, it has been concluded that the Muslim courtiers require the capacity to cope and accustom new technologies for their local requirements. It is misunderstood that the technology can be easily transferred and diffused by applying outside knowledge and equipment. In fact, human skill development, ability and knowledge are required to learn, apply and adopt new technology in home country. Unfortunately, Muslim countries are lagging behind in the field of science and technology, research and development. Therefore, Muslim countries should not only enhance the capacity building to adopt foreign technologies but also focus on research and development, so that, they would be able to develop new technologies to fulfill their local needs. Muslim countries should produce and enhance their own technology, creativity by applying both local and global knowledge and science. Significant steps to improve technological progress in Muslim countries are needed.

Most of the Muslim countries are lagging behind in diffusion of old inventions (telephones and electricity). Rural communities and poorer families are still deprived of these basic technologies as these two basic technologies are structural and functional unit of technological progress and links to the new technologies driving progress in the 21st century. It is a fact that without electrification, the technology cannot be diffused widely and the capacity to innovate cannot be attained which is essential to transform into patents or royalties at a significant level.

The development of human skill is essential to attain technological capability. Although, a few Muslim countries perform well in gross enrollment ratio but still they lag behind in achieving 100% literacy rate. The gross enrollment ratio of students in science at universities and other tertiary level is not very impressive in all Muslim countries. In this era of fast technological advancement, basic education is essential for inhabitants of a country to use any new technologies. The question is that; is the education system of Muslim courtiers adequate to meet the new challenges of 21st century? The answer is no. Therefore, to enhance the human skill, all the Muslim countries are required to raise their educational and R&D budget. They should allocate at least 2% share of their total GDP for education and 1% for R&D as recommended by World Bank and UNESCO.

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