Transforming the United Arab Emirates into a knowledge-based economy

The role of science, technology and innovation

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Abstract

Purpose – This paper aims at exploring the role of science, technology and innovation (STI) in transforming the United Arab Emirates (UAE) into a knowledge economy (KE) by initially assessing the country's achievements implementing the KE pillars. It further evaluates the country's STI capacity and competence in exercising adoption and diffusion of knowledge.

Design/methodology/approach – A situational analysis and a comparative approach were exploited to describe the UAE's position in terms of transition to a KE, highlighting weaknesses, strengths and opportunities. Related discussions were supported by data made available from several international sources. The country's worldwide performance was particularly matched against that of the other members of the Gulf Cooperation Council (GCC) together with two more Asian transformation economies and also a few examples from other Arab and Muslim countries.

Findings – Apparently, the UAE has made important progress in the implementation of the KE pillars and transitioning to the innovation-driven stage, particularly at the macro-economic environment and quality of infrastructure levels, notably the ICT sector. However, the county is facing several challenges that require concerted efforts and rigorous follow-up. For instance, the UAE is lagging behind most transformation economies and some GCC countries when it comes to investment in education and R&D activities. This hurdle impeded the country's ability to absorb, adapt and create new technology and knowledge. As a result, the country's economy is experiencing a negative trade balance in foreign technology transfer. The comparative and situational analysis methodology adopted in the context concluded several lessons and policy remarks.

Originality/value – Using the most updated data, this exercise stems from the country's need to examine the current status, a necessary step for realization of new prospects and adoption and application of future policies and programs.

Keywords Knowledge economy, STI, GCC countries, R&D, Assessment, United Arab Emirates
Paper type Research paper

1. Background and objectives

United Arab Emirates (UAE), a member state of the Gulf Cooperation Council (GCC), has enjoyed an impressive economic growth over the last few years, with sustainable rise in growth domestic product (GDP) per capita ranging from 18.5 thousands US dollars in 1990 to 30.4 thousands in 2008, apparently coinciding with high oil revenues and high growth in the labour force from 694.2 thousands in 1990 to 3.3 million in 2008 dominated by foreign workers (for more details see UAE Ministry of Economy annual reports). UAE ranks within the top 40 countries in the latest HDI (third in the MENA

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region, after Saudi Arabia and Iran), such a good performance is argued by several scholars as a good indicator for a strong economy and a well balanced.

Table I presents the performance of UAE against the rest of the world and Arab/Muslim countries using different international indicators and measurements. These various global indicators will help in understanding the position of UAE according to a set of measures that are recognized internationally.

Using various international reports and databases, the above table compares the UAE's performance (world ranking) with the rest of the world with regard to the most widely accepted indexes such as human development index (HDI)[1]; gross national income (GNI)[2]; knowledge economy index (KEI)[3]; global innovation index (GII)[4]; global competitiveness index (GCI)[5]; and environmental performance index (EPI)[6].

Moreover realizing the wide knowledge gap between countries in the GCC region and the developed world in the west and Asia and that stability and sustainability, not only high growth and high returns, are vital for the development of the economy, almost all members of the GCC are attempting diversification route that underscores knowledge as the driving force in economic activities.

In addition to noticeable initiatives towards creating sustainable employment opportunities for UAE nationals, the country has recently embarked on genuine diversifications moves intended to reduce dependency on hydrocarbons and to achieve the transition to a knowledge economy (KE). The process involved raising awareness about the fundamental concepts of KE across the private and the public sectors in line with the UAE vision 2021 and the federal strategy 2011-2013. By moving to innovation and KE stage, the UAE can reap huge benefits in terms of economic growth, global market reach and less dependence on a single commodity sector, currently, according to the International Monetary Fund (IMF) data for 2007, oil exports represent 25.7 per cent of the country's GDP, the least compared to other GCC countries. Further envisaged KE benefits embrace socio-political stability and prosperity and enhanced productivity as a result of injecting new skills into the labour force. It is noteworthy that the current diversification trend in the UAE is dictating different pace across the different emirates forming the union. The Emirate of Dubai, for example, has succeeded in diversifying 90 per cent of its economy away from hydrocarbons, while Abu Dhabi Emirate's economy is still 66 per cent hydrocarbon-based (see Wilson, 2010).

Countries	HDI 2011	GNI 2011	KEI 2012	GII 2011	GCI 2012	EPI 2012
World top	0.943	–	9.43	63.82	5.74	*76.69*
World bottom	0.343	–	0.96	19.79	2.87	*25.32*
World average	0.682	10,082	5.12	–	–	–
Arab average	0.641	8,554	4.74	–	–	–
United Arab Emirates	*0.846*	*59,993*	*6.94*	*41.99*	*4.89*	*50.91*

Notes: HDI (Value – 187 countries); GNI (Constant 2005 PPP $ – 187 countries); KEI (Value – 146 countries); GII (Value – 125 countries); GCI (Score – 142 countries); EPI (Score – 132 countries)
Sources: Adopted from Human Development Report (2011), KEI (2011), INSEAD (2011), WISR (2006 and 2007), ITU World Telecommunication Indicators Database; Yale Centre for Environmental Law and Policy (various years), Human Development Report (2006), World Economic Outlook Database (2007) and World Economic Forum (WEF) (2006-2011)

Table I.
UAE performance versus the world (latest reports/data)

The Emirate's desire to build a diversified economy, however, has prompted "The Abu Dhabi Economic Vision 2030", a long-term strategy, launched 2009, seeking to reduce reliance on the hydrocarbon-based sector as a source of economic activity, increasing the contribution of non-hydrocarbon-based sectors to the Emirate's GDP and focus on knowledge-based industries in the future.

Indeed, to make the transition into a KE, the UAE Vision 2021 advocates increasing investment in science, technology and innovation (STI) and research and development (R&D). Countries such as Singapore and the Republic of Korea who have invested substantially in knowledge components over the past few decades, have experienced rapid and sustained economic growth and are currently among the most dynamic and competitive economies in the world, ranked 2nd and 24th, respectively, according to the GCI for 2011-2012.

Acknowledging the importance of knowledge for long-term economic growth, the World Bank introduced the KE framework[7] which asserts that sustained investments in education, innovation, information and communication technologies (ICTs) and creating a conducive economic institutional environment will lead to increases in the use and creation of knowledge in economic production, and subsequently result in sustained economic growth (Chen and Dahlman, 2006).

The main objective of this paper is to assess the UAE's position with regard to implementation of the KE pillars relating to STI and to evaluate the country's performance in terms of transition to a KE and global competitiveness. This exercise stems from the country's need to examine the current status, a necessary step for realization of new prospects and adoption and application of future policies and programmes. The rest of the paper develops as follows. Section 2 lays the study methodology and data sources. Section 3 assesses the UAE performance with respect to transition to a KE based on the KEI, the knowledge index (KI) and several other KE indicators. Section 4 evaluates in detail the country's STI capacity and policy. Section 5 draws some concluding remarks, lessons and policy recommendations.

2. Methodology and data sources

A situational analysis and a comparative approach were exploited to describe the UAE's position in terms of transition to a KE and global competitiveness, highlighting weaknesses, strengths and opportunities. In particular, the exercise evaluated the UAE experience within its GCC regional domain together with that of two transformation economies, namely: Singapore and the Republic of Korea. In the context, the World Bank Knowledge Assessment Methodology (KAM) (www.worldbank.org/kam) was utilized to provide an overview of the UAE's and the other selected countries world-wide performance based on the four pillars of the KE. Eventually, the KAM KEI and the KAM KI were deployed to gauge the conduciveness of the country's environment for an effective use of knowledge in the economic development process and to assess the country's competence in exercising adoption and diffusion of knowledge.

The UAE global competitiveness and related analysis and discussions drew on the most recently available international data, including the World Bank Knowledge for development (K4D) data sources and data and measures made available from the World Economic Forum (WEF) 2011-2012 Global Competitiveness Report (GCR). The KEI and KI indices and several other KAM descriptive tools generally rely on a set of normalized indicators (with values ranging from a minimum of 0 to a maximum of 10) that are measured for a reference year, 1995, and for the most recent period,

governed by availability of data. It is important to note that the KEI represents a simple average of the normalized values of the 12 knowledge indicators shown in Figure 1. The KI is also a simple average of indicators representing three key KE pillars indicated in Figure 1. Some of the KAM indicators are usually weighted by the country's population size in order to control for the effect of strong economies.

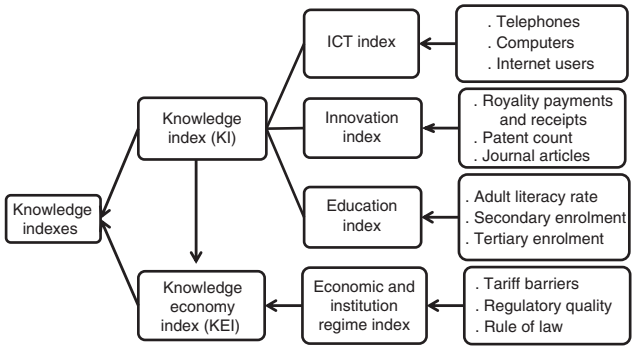
3. UAE overall performance as a KE

The concept "KE" is currently utilized to describe an economy that creates, disseminates and uses knowledge to enhance its growth and development. According to the World Bank (2005b), a successful KE is characterized by close links between academic science and industrial technology, empowered by increased education and lifelong learning, and greater investment in intangibles such as R&D and software. It places greater importance on innovation for economic growth and competitiveness. Application of knowledge in the economy implies efficient ways of production and delivery of goods and services at lower costs and to greater population size. It, therefore, entails investing in strategies that produce significant changes in the way a country can grow (Salmi, 2009).

Using the World Bank's KAM, Table II presents the recent performance of selected Arab/Muslim countries as illustrated by the World Bank's KEI 2012 including 146 economies across the world. Table II also compares the current performance (KEI, 2012) with countries KEI 2000 (see Ahmed and Al-Roubaie, 2012). It is therefore clear from the analysis below that the picture across most Arab/Muslim counties varies from economies with impressive progress towards the knowledge-based economies such as UAE to economies with large decrease in their KEI such as Kuwait.

According to the 2012 World Bank's KEI, UAE excels in 2012 with remarkable improvements towards the knowledge-based economy and, has scored 6.94 and rank 42nd in the world and leading the Arab and Muslim countries (see World Bank, 2012).

Figure 2 portrays the UAE performance in 1995 and recently (2009), measured using the KEI. It demonstrates the country's preparedness to compete in the global KE, benchmarked against its GCC neighbours and other selected countries, namely, Singapore and the Republic of Korea who succeeded in making great strides in transition to knowledge-based economies. Countries in Figure 2 below the 45° regression line have improved their present (2009) performance on the KE indicators compared to 1995, and those below the line have slipped. Accordingly, the UAE, together with Qatar, demonstrated an improved performance in the KE ladder



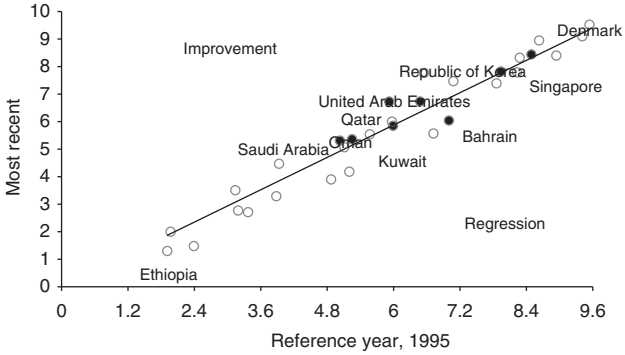
Source: World Bank Knowledge for Development (K4D)

Figure 1.
Variables (indicators) forming the KEI and the KI indexes

Country	KEI	Rank	Change[a]
Sweden	9.43	1	–
Economies with large improvements in KEI rankings since 2000			
United Arab Emirates	6.94	42	+6
Oman	6.14	47	+18
Saudi Arabia	5.96	50	+26
Tunisia	4.56	80	+9
Iran	3.91	94	+1
Algeria	3.79	96	+14
Pakistan	2.45	117	+5
Nigeria	2.2	119	+5
Yemen	1.92	122	+6
Sudan	1.48	138	+1
Economies with decreases in KEI rankings since 2000			
Bahrain	6.9	43	−2
Malaysia	6.1	48	−3
Qatar	5.84	54	−5
Kuwait	5.33	64	−18
Turkey	5.16	69	−7
Jordan	4.95	75	−18
Lebanon	4.56	81	−13
Egypt	3.78	97	−9
Morocco	3.61	102	−10
Syria	2.77	112	−1
Bangladesh	1.49	137	−3
Myanmar	0.96	145	−8

Note: [a]Changes in KEI ranks from 2000
Source: World Bank (2012)

Table II.
Arab/Muslim countries KEIs with large improvements and reversals, 2012



Source: KAM 2009 data

Figure 2.
KEI for the UAE and selected countries (1995 and most recent year)

compared to 1995, both topping the GCC list with a KEI of 6.73 at present (2009). This indicates a faster change of 0.81 for Qatar compared to 0.25 for the UAE (see Table III).

The two countries, however, performed significantly lower than Singapore and the Republic of Korea. Benchmarked against 1995 KEI values, both Saudi Arabia and Oman have also reported improved performance, reflecting a positive change of 0.28

Country	Knowledge economy index (KEI) Most recent	1995	Change
Singapore	8.44	8.49	−0.05
Republic of Korea	7.82	7.94	−0.12
Qatar	6.73	5.92	0.81
United Arab Emirates	6.73	6.48	0.25
Bahrain	6.04	7.00	−0.96
Kuwait	5.85	5.99	−0.14
Oman	5.36	5.25	0.11
Saudi Arabia (KSA)	5.31	5.03	0.28

Source: KAM 2009 data

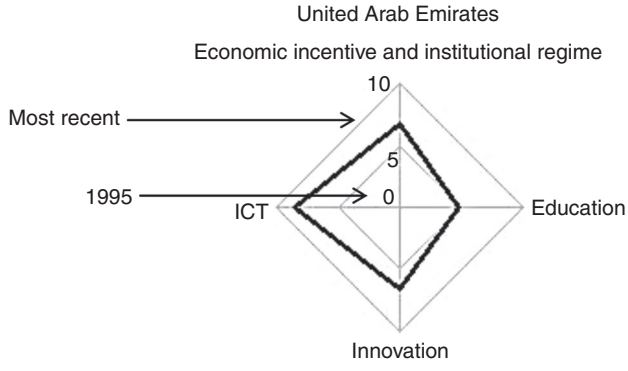
Table III.
KEI for 1995 and the most recent year

and 0.11, respectively. The rest of the countries in the comparison group, have shown varying levels of deterioration (negative change) in the KEI values, ranging from a minimum of 0.05 in Singapore to a maximum of 0.96 in Bahrain (Table III).

A careful inspection of the four pillars of KE depicted in Table IV and Figure 3; namely, economic incentive, education, innovation and ICT, reveals that the UAE has witnessed a significant upturn in the ICT sector in recent years. Matched with other GCC countries, the UAE ranked top in terms of the ICT knowledge component and

Index	UAE	Qatar	Bahrain	Kuwait	Oman	KSA	Korea	Singapore
KEI	6.73	6.73	6.04	5.85	5.36	5.31	7.82	8.44
KI	6.72	6.63	5.80	5.63	4.77	5.10	8.43	8.03
Economic incentive and institutional regime	6.75	7.05	6.75	6.50	7.15	5.94	6.00	9.68
Education	4.90	5.37	5.82	4.93	4.47	4.89	8.09	5.29
Innovation	6.69	6.45	4.29	4.98	4.94	3.97	8.60	9.58
ICT	8.59	8.06	7.30	6.96	4.90	6.43	8.60	9.22

Table IV.
KEI, KI and the four pillar of the KE for the UAE, GCC and other countries for the most recent year



Source: KAM 2009 data

Figure 3.
KEI of the four pillars for the UAE 1995 and most recent year

efficient performance of innovation system of firms as well as in the overall KI (see Table IV).

In economic incentives and institutional regime, the country performed better than Saudi Arabia (KSA), stayed in the same line as Bahrain, but lagged behind Oman, Qatar and Singapore. The area where no real improvement (between 1995 and 2009) was sighted is education (see Figure 3).

Generally, the country is showing progressively satisfactory moves in the implementation of the KE pillars. The overall performance and development pattern, in the key KE components, summarized by the KEI and the KI using recent KAM 2009 updated data, remained better than other GCC countries, yet, the country is showing a lower performance in the education pillar and is dropping behind the more dynamic economies of Singapore and the Republic of Korea, in almost all KE indicators (see Table IV).

4. STI in UAE

4.1 GII

Based on the recent GII 2011 published by INSEAD (2011), Table V provides an overview of some selected Arab countries with high performance in terms of innovation outputs surmounting weaknesses from the input side and those that lag behind in fulfilling their innovation potential. From the analysis in Table V, UAE scores 41.99 and ranked 34th in the world and 2nd among the Arab countries after Qatar which is ranked 26th in the GII 2011.

The principal challenges facing UAE and most Arab countries revolve around an inability to create knowledge and generate innovation to support the KE. Building capacity for STI in UAE by strengthening knowledge production, knowledge sharing, knowledge distribution, knowledge transfer, technological learning and skill development is an essential condition to create a knowledge-based economy. In this endeavour, collaboration on the part of the public and private sectors is essential to generate linkages within various sectors of the economy. Moreover, GII 2011 highlights the needs for Arab countries to formulate carefully crafted policies that focus on

Rank	Country	Score
26	Qatar	47.74
34	*United Arab Emirates*	*41.99*
41	Jordan	38.43
46	Bahrain	37.8
52	Kuwait	36.64
53	Mauritius	36.47
54	Saudi Arabia	36.44
57	Oman	35.51
66	Tunisia	33.89
87	Egypt	29.21
94	Morocco	28.73
115	Syria	24.82
123	Yemen	20.72
124	Sudan	20.36
125	Algeria	19.79

Table V.
Arab countries innovation index, 2011

Source: INSEAD (2011)

creating linkages between the local and global knowledge systems without succumbing to the pitfall of falling into undue dependency on global knowledge. Such dependency risks sacrificing long-term interest in favour of short- and medium-term inasmuch as it entails forfeiting the building of capacity to generate indigenous knowledge. Without indigenous knowledge, development will be constrained, if not hobbled, by foreign knowledge in the long term.

4.2 Education system

Transition to a KE is greatly dependent on the development of innovation capacities which are strongly interlinked with the level of education, qualifications and skills building in the community (see Zahlan, 2007; Ahmed and Al-Roubaie, 2012). The Executive opinion survey of the WEF of 2011-2012, revealed that, from a list of 15 factors, inadequately educated workforce represent the third top problematic factor for doing business in the UAE. Quantity and quality of Education, however, particularly basic education, are important prerequisites for increasing productivity and work efficiency. A workforce with little formal education is inclined to producing limited simple manual products, lacking the right skills and capability to absorb new technology and generate new ideas and innovations that promote productivity and bring about new products. Recent growth in the UAE economy was marked by an increase in low skilled and low pay labour force, Abdalla *et al.* (2010).

According to the last UAE census in 2005, foreign workers represent more than 92 per cent of employed workforce, around 11 per cent are illiterates, 16 per cent are able to read and write and around 53 per cent have an education level between primary and secondary. Slightly more than 20 per cent have an educational level above secondary school (diploma, university degree, masters degree or PhD). Assuming that workers with secondary education or above are skilled, Al Awad (2010) indicated that the percentage of unskilled workers in the UAE represent 80 per cent of the employed labour force. If left to market forces, profit maximizing employers in the private sector will prefer to continue to hire foreign workers at a significantly lower wage rates. However, building a modern KE requires more investment in acquiring advanced technologies and high levels of competency in the workforce. Today's globalizing economy requires countries to nurture pools of well-educated workers who are able to adapt rapidly to their changing environment and the evolving needs of the production system (GCR, 2011-2012). The UAE is, therefore, in a great need to have in place a mix of policies and plans that can help shift up the skill level of the labour force in the country.

The percentage of adult literacy in the UAE among the population aged 15 years or more is 90.45 per cent, similar to Qatar's percentage and second after Kuwait, when compared within the GCC countries domain. In this context, Singapore and the Republic of Korea have reached 94.43 and 97.90 per cent in literacy rates, respectively. Gross secondary education enrollment rate reached 92.37 per cent, only better than Oman and Kuwait percentages, 89.77 and 88.71, respectively. These can be compared to Singapore's and the Republic of Korea's rates of 63.18 and 97.50 per cent, respectively. In tertiary education the UAE scored a gross rate of 22.85, fourth place GCC-wise after Bahrain (32.05), Oman (25.49) and Saudi Arabia (30.24). In this domain, Singapore and the Republic of Korea achieved higher growth rates of 55.9 and 94.67, respectively.

Education figures based on UNESCO data sources reflect the UAE poor performance in terms of expenditure on education. In 2006, the country devoted

only 1.1 per cent of its GDP to education, the lowest compared to the Republic of Korea (4.2 per cent) and all other GCC countries, Saudi Arabia (6.2 per cent), Oman (3.9 per cent), Kuwait (3.8 per cent) and Bahrain (3.4 per cent). Similar spending pattern persisted throughout 2007 (<1.0 per cent) and 2009 (1.2 per cent). Nevertheless, according to the GCR of 2011-2012, the UAE has made significant progress in secondary (95.2 per cent) and tertiary (30.4 per cent) education enrollment compared to 2009 KAM figures, in par with KSA (96.8 per cent) and Bahrain (96.4 per cent) in secondary level, better than the performance of the rest of the GCC countries, but still below that of Singapore and the Republic of Korea in both levels. In Singapore, for instance, education is highly subsidized by the government, constituting the second largest expenditure item, providing the country with higher technical skills and training needed for high-technology production (Radwan and Pellegrini, 2010).

It is instructive to note that the higher education sector in the UAE has witnessed a large expansion with the number of licensed colleges and universities increased from five in 1997 to about 58 in 2008, including some foreign universities who established branch campuses, Hijazi *et al.* (2008). Only three of these institutions are government funded institutions; namely, the UAE University, Zayed University and the High Colleges of Technology. The expansion in higher education opportunities was mainly driven by the high economic growth in the UAE economy and the increase in investments made by the private sector in higher education institutions in the Gulf region in general, Lefrere (2007).

To improve the quality of education at the public universities the UAE Government thought various initiatives, including seeking accreditation of both institutions and individual academic programmes from mainly North American higher education accreditation agencies. Similar internal agencies were established to oversee the quality of education within the private institutions; these include the UAE Commission for the Academic Accreditation (CAA), and the Knowledge and Human Development Authority in Dubai. Despite these progressive improvements in the size and the quality of higher education, there still remains a significant mismatch between the UAE labour market needs and the kind of specializations obtained by graduates of the UAE higher education institutions, Hijazi *et al.* (2008). As of the 2005 figures, about one-third of the higher education graduates studied STI curriculum and the other two-thirds were graduates of social sciences tracks, a result which does not support labour market needs and future plans to increase growth in the innovation system which is very much in need to development of human resources in engineering, science and technology.

Reviewing the quality of the education system, the 2011-2012 GCR positioned the UAE 29th, far below the ranking of Singapore (2nd), Qatar (4th), Saudi Arabia (25th), but better than the Republic of Korea (55th), and the rest of the GCC countries, Kuwait (108th), Oman (46th) and Bahrain (31st). Indeed, the current world-wide position of the UAE education system (29th) has prompted the 2011-2012 GCR to suggest prioritizing further investment to boost educational outcomes, arguing that raising the bar with respect to education will require not only measures to improve the quality of teaching and the relevance of curricula, but also incentivizing the population to attend schools at the primary and secondary levels as well.

4.3 Digital opportunity index (DOI)

According to various WISR report (2006-2010) reports, the DOI[8] is the only e-index based solely on internationally agreed ICT indicators, developed for 181 countries in 2006.

This makes it a valuable tool for benchmarking the most important indicators for measuring the Information Society.

There is enormous variety in the socioeconomic context of Arab countries, and a related large variability between them in terms of their current status with respect to IT, in areas such as their existing equipment base, the availability of trained personnel, and their current levels of usage of IT/S. According to the latest DOI and WEF (2011), the UAE continues to lead the Arab world in the adoption of ICT and is expected to spend about USD 3.3 billion on ICT hardware for schools, hospitals and other civil projects for the period 2008-2011.

The index also reveals an alarming picture for many countries in the region moving backward across the table from 2005 to 2011 world ranking. The ranking of rich countries like Kuwait (moved from 49th in 2005 to 60th in 2006) and Saudi Arabia (moved from 72nd place in 2005 to 75th place in 2006) showing that a nation's economic status does not always correspond to its path towards the Information Society. Bartholomew (1997) argues that technology development is embedded in a country's history, cultural values and attitudes. Therefore, attitude to IT could also have something to do with national culture. Therefore in the case of Saudi Arabia and Kuwait and indeed in some other parts of the region, the lack of success to move forward could be linked to Freedom of Information issues. No doubt that free access to the internet and information are very much dependent on the political climate and levels of information censoring in a country (see Ahmed, 2005). High levels of governments' censorship usually impede rapid progress towards a successful information society.

Moreover, based on KAM most recent data, the country has reported the highest penetration rate of 2.1 telephones per 1,000 population compared to all other GCC countries, Singapore and the Republic of Korea. It also reported the highest rates of computers (330 per 1,000 population) and internet users (520 per 1,000 population) among other GCC countries, yet lower than Singapore (740 and 660 per 1,000 population, respectively) and the Republic of Korea (580 and 760 per 1,000 population, respectively).

4.4 R&D activities

Most private companies in the Middle East and North Africa (MENA) and the GCC region lack the incentives, capacity and skills to innovate, (UNDP, 2002, 2003). Only 3 per cent of the R&D in the Arab countries is funded by the private sector compared to more than 5 per cent in OECD countries.

The UAE ranked 32 out of 142 countries in terms of the capacity of its companies and people to create and then commercialize new products and processes (GCR, 2011-2012), positioned in the 3rd place within the GCC context, after Qatar (11th) and KSA (21st), and below Singapore (22nd) and the Republic of Korea (20th). Among the basic foundations of a country's innovation infrastructure is its R&D activities and the pool of scientists and researchers able to play part and contribute to innovation and the creation of new technologies (Chen and Dahlman, 2006).

Outcomes of the R&D activities can be realized and measured utilizing a number of indicators, including government and private sector spending on the education system and research, and collaboration between the industry and research institutions. Although the GCC countries have maintained developed world levels of GDP per capita, yet investment in R&D remains at developing world levels, McGlennon (2006).

The UAE performance on "company spending on R&D" and "University-industry collaboration in R&D" ranked 24th and 37th world-wide, respectively, trailing most

industrialized and transformation economy countries including Singapore (10th and 6th) and the Republic of Korea (11th and 25th). Within the GCC region the country's performance is average, occupying the 3rd place after Qatar (20th and 10th) and KSA (18th and 28th). Disclosure of information about the level of financial resources devoted to R&D in the UAE are scarce, most of the available information are based on estimation made by international sources.

A collective review of spending on R&D activities in the GCC countries, of which the UAE is no exception, reveals the public sector as the main contributor, accounting for 49.4 per cent of the total R&D spending by all sectors and institutions, Nour (2005). Universities in the region also provide a sizable contribution of about 43.5 per cent, leaving the private sector with a minutiae share of 7.1 per cent. Given the strong link between R&D and innovative activities required to sustain growth and development, the private sector in the GCC countries is thus playing an insignificant role in the process of transfer to KE. It largely tends to utilize research done by international companies, UNDP (2009). Compared to the Republic of Korea, the private sector there has succeeded in increasing the country's indigenous innovation and in promoting inward transfer of foreign technologies and development of domestic innovation and production capacity, by mainly relying on R&D, (World Bank, 2006).

According to UNESCO, the Korean investment on R&D activities, as a share of the country's GDP increased from 2.48 per cent in 2004 to 3.36 per cent in 2008 with the private sector accounting for about three-quarters of this share. Similar pattern of increase of investment in R&D can be noted in the Singaporean model, with a share of GDP increased from 2.13 per cent in 2004 to 2.66 in 2008. It is informative to note that the Singaporean Government plays a very active role in innovation by stimulating private sector R&D through allocating significant funds to support public sector R&D and by setting strategic directions intended to promote specific industries (Radwan and Pellegrini, 2010).

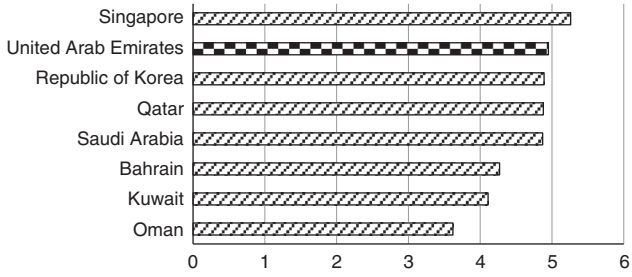
In 2008 the UAE government established the "National Research Foundation (NRF)" with a vision to bring together all universities and research institutions in the country and to support world-class research activities, and create an internationally competitive research environment and innovation system. The expected outcomes of these research activities are envisaged to bridge the gap between the UAE and the industrialized countries in technology absorption and creation, and to enhance productivity and enable the businesses of the UAE to be more competitive. Over the ensuing years the foundation received and vigorously reviewed, employing international standards, a significant number of grant proposals in science, technology and social science disciplines, on the basis of National Priorities Research programme, covering almost all universities and colleges in the country. However, it was unfortunate that the launch of the NRF programme coincided with the 2008 world economic crisis, resulting in major funding cuts and delays in the grant awarding process. The contributions of the NRF towards fulfilling its mission and bringing up the scientific and research community closer to the business and the labour market needs are yet to be realized. The country could immensely benefit from the experience of several successful transformation economies and adapt similar models that can also yield to domestic boundaries and constraints.

4.5 Knowledge production: size and quality of research publications

Useful and frequently used indicators to gauge scientific activities in a country is to assess availability of scientists and engineers in the country and the number of

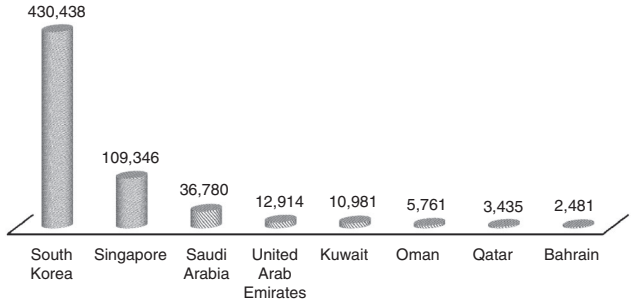
research publications in refereed international journals per populations. According to the GCR of 2011-2012, the UAE scored 4.95 points on availability of scientists and engineers, the score is based on a 1 to 7 scale, a value of 7 means that scientists and engineers are widely available while a value of 1 means that they are non-existent. This good score positioned the country top of all GCC countries and the Republic of Korea (see Figure 4). The actual implication of this outcome is that the UAE entertains high potentials to advance research and innovations in both size and quality.

However, the country's performance in the international list of published research (1996-2010) stayed low, scoring 12,914 published papers in this period (Figure 5). This statistic positioned the country second after Saudi Arabia, GCC-wise and 66 worldwide. The statistic can also be interpreted to imply the country's inability to utilize and incentivize the widely available pool of researchers in its arena. Despite the fact that Saudi Arabia and the Republic of Korea have smaller pools of scientists and engineers than the UAE (Figure 4), their share of internationally published research is almost three times and 33 times than that of the UAE, respectively (Figure 5). This disparity could partially be attributed to lack of sufficient funds. The UAE is, therefore, in a great need to initiate proactive measures and social conditions to enable a process of cooperation and interaction between scientists and researchers domestically. Such a process of cooperation and interaction, particularly in science and technology, would lead to improving the conduct of scientific research and to increasing the number of co-authored publications as well as ensuring quality and success of scientific enterprises, (Zahlan, 2007).



Source: World Economic Forum (WEF) (2011-2012)

Figure 4.
Availability of scientists and engineers



Source: SCImago (2007)

Figure 5.
Research publications (1996-2010)

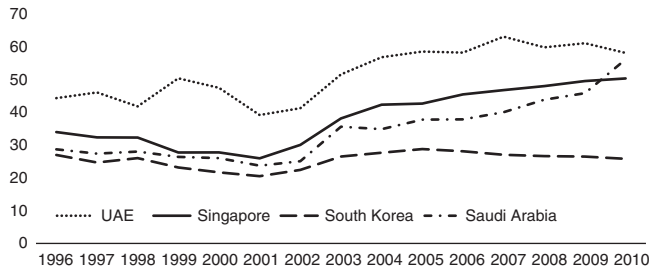
Based on the Hirsch index (H-index), using SCImago (2007) updated database for 2012, the quality and impact of research published by UAE scholars (1996-2010), received an H-index value of 72, ranking the country 66th in a list of 236 countries world-wide. This position placed the UAE above all other GCC countries, except Saudi Arabia who scored 106 which ranked it 50th. Singapore H-index was 218, placing the country 32nd and the Republic of Korea scored 287, securing rank 14 in the list. Evaluating quality of published work in terms of the number of citations per document, the UAE, in parity with Kuwait, occupied the top of the list GCC-wise with scores of 7.02 and 7.06 citations per document, respectively, below both Singapore and the Republic of Korea's scores of 11.82 and 9.82, respectively. Evidence indicates; see Figure 6, an increasing trend in the level of the UAE internationally collaborative research. More than 58 per cent of research documents published by UAE scholars during 1996-2010 were co-authored with researchers from foreign institutions, SCImago (2007). A similar trend, albeit on a lower scale, can be observed for Saudi Arabia (see Figure 6).

The tendency of the UAE and other Arab world scientists towards international collaboration, as suggested by UNDP (2009), is prompted by the lack of domestic funding and that most of the industrialized countries encourage their scientists to collaborate internationally. Further explanations highlight the growing connectivity between scientists world-wide, and more importantly the tendency of UAE employed professors, mainly expatriates, to keep ties and links with their own countries and institutes of origin, Bachellerie (2010). Countries such as the Republic of Korea, have managed to increase private sector investment in R&D, and succeeded in promoting inter-country research connectivity as well as benefiting from international programs and partnerships. One quarter of Korea's research production over the period 1996-2010 was a result of global cooperation, Figure 6.

In 2007, the Statistical, Economic and Social Research and Training Centre for the Islamic Countries (SESRTCIC), ranked the UAE University (UAEU), the biggest publically funded institution in the country, number 9 out of 84 universities in the Islamic countries, top of all universities in the GCC countries. In research quality, measured as the number of citations per published papers, the UAEU scored an average of 0.53, and in research performance, measured by the number of published papers per number of faculty, the university scored 0.40, both scores positioned the UAEU among the 20 top universities in the Islamic world.

4.6 Publications in STI and patents grants

Publications in STI are used as an indicator of the ability and competence of researchers in a country and as a measure of the country's future potential for



Source: SCImago (2007)

Figure 6.
Percentage of country publications with international collaboration (1996-2010)

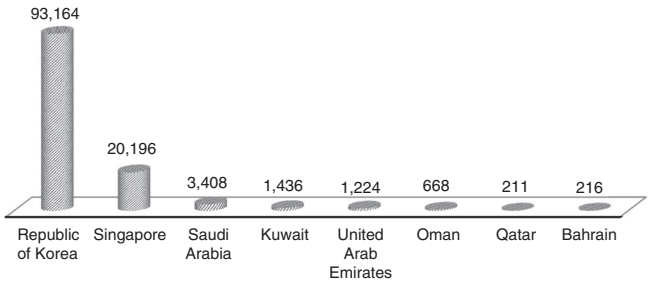
innovations and technical developments. GCC-wise, the UAE publications in this category are third place after Saudi Arabia and Kuwait (see Figure 7). However, the country's performance in this category, compared to the two benchmark innovation-driven economies, Singapore and the Republic of Korea, is very low, representing respectively, about 6 and 1 per cent of their publications in science and technology (Figure 7).

Bachellerie (2010) and Zahlan (2012) show that in the period from 1995 to 2009, science and engineering publications reached a total of 4,925 papers covering 16 UAE universities, representing 93 per cent of the total national science publications, stressing the dominance of universities in UAE scientific production. The majority of these published papers were in the field of Medicine followed by papers in Engineering. The UAE University dominated the distribution of the production with over 60 per cent of the total published science and engineering papers, followed by the American University of Sharja with 11 per cent, Sharja University with 9 per cent, the Petroleum Institute with 5 per cent and the rest went to other universities in the country. More than 80 per cent of these publications were a result of international cooperation, again reflecting the low level of local cooperation among researchers in the UAE. Empowering the UAE NRF initiative with the needed resources and power to bring together all universities and research intuitions in the country, would help in developing and sustaining research capacity in areas that are of relevance to domestic needs, encourages exchange of ideas and information and creates a scientific research system in which internal and external cooperation generates new knowledge and encourages patents and innovative thinking.

Granted utility patents are usually utilized as indicator to provide a measure of the level of R&D and innovation capabilities in a country, World Bank (2006). During the period from 1997 to 2010, the UAE filed 85 patents to the US Patents and Trademarks Office (USPTO), representing 1.49 per million populations (Figure 8). This is an average performance when UAE is compared with regional GCC counterparts, but very weak compared to industrialized countries and emerging transformation economies of Singapore (125.63 per million populations) and the Republic of Korea (240.64 per million populations).

5. Conclusions and policy recommendations

Acknowledging the importance of stability and sustained economic growth, the UAE is seeking to achieve economic diversification and the transition to the KE. The country has succeeded in reducing dependency on oil as a dominant commodity far more compared to its GCC counterparts.



Source: World Bank Databank

Figure 7.
STI publications (2002-2007)

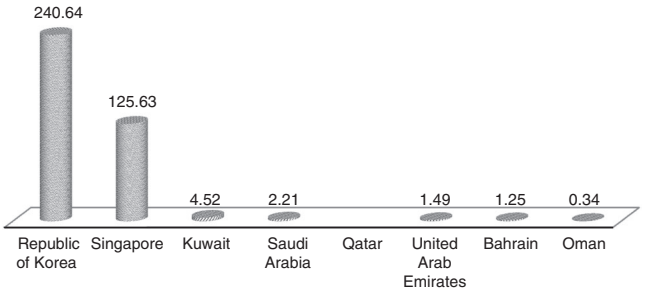


Figure 8.
Utility patents per million population

Source: World Economic Forum (WEF) (2011-2012)

The analysis and discussion conducted throughout this paper drew on several international data sources that provided the basis for demonstrating the UAE's innovation capacity and preparedness to compete in the global KE. The country's performance was evaluated worldwide and benchmarked against that of neighbouring GCC countries together with other examples from the Asian transformation economies.

Evidence reveals a positive progression of the UAE in transitioning towards the innovation-driven stage; characterized by a high performance macro-economic environment and a high quality infrastructure, particularly in the ICT sector. However, several issues remain a concern and challenges remain to be addressed. In recent years, the country's economy experienced negative trade trends in foreign technology transfer, exhibited low investments in education and R&D activities and a lack of ability to absorb, adapt and create new technology and knowledge.

The UAE needs to increase its investment in education and R&D activities by increasing public expenditure, at least to match industrialized nations' minimum level, and by encouraging more private sector contributions. Investment in the education and the R&D sectors should be coupled with strategic reforms that ensure aligning learning and research outcomes to meet labour market demands and KE requirements. Particular focus should concentrate on strengthening technical and vocational training and revamping of curricula, particularly, at the higher education level, where learning outcomes should emphasize promotion of critical thinking skills together with creativity and problem solving capacities. This is instrumental in providing high skilled professional workforce to counteract the current mismatch in supply and demand in the country's human resources. It is also instrumental in providing R&D manpower required to improve the country's ability to adapt and assimilate new technologies and to develop an innovation base. UAE investment in knowledge inputs would benefit the country's competitiveness standing and would increase its chances of achieving sustained productivity growth as a result of increasing the indigenous innovation and the domestic value added of its goods and exports.

The UAE needs to emphasize more interaction and collaboration among all constituents in the R&D sector, including the government, the private sector and the wide pool of scientists and researchers in its universities and research institutions in order to improve research efficiency and to increase the size and quality of research output.

Overall, it is clear that the UAE endeavour to joining the KE club is supported by a well-established physical and communications infrastructure and clear strategic objectives and priorities to diversify the economy away from the hydrocarbon-based economic activities. The country's commitment to transitioning to a KE is receiving

the required political backing and is further supported by availability of significant financial resources and wealth that can play proactive part in realizing the KE vision. The key to achieving sustainable economic growth and stability, however, hinges on the optimal utilization of these assets in production and development, embracing the KE fundamentals and promoting entrepreneurship, innovation and global competitiveness.

Notes

1. HDI: a composite index measuring average achievement in three basic dimensions of human development – a long and healthy life, knowledge and a decent standard of living.
2. GNI per capita: aggregate income of an economy generated by its production and its ownership of factors of production, less the incomes paid for the use of factors of production owned by the rest of the world, converted to international dollars using purchasing power parity (PPP) rates, divided by midyear population.
3. The World Bank's KEI is an aggregate index representing a country's or region's overall preparedness to compete in the KE. The KEI is based on a simple average of four sub-indexes, which represent the four pillars of the knowledge economy: Economic Incentive and Institutional Regime (EIR); Innovation and Technological Adoption; Education and Training; and Information and Communications Technologies (ICT) Infrastructure.
4. GII 2011 published by INSEAD in collaboration with its knowledge partners (Alcatel-Lucent, Booz and Company, the Confederation of Indian Industry and the World Intellectual Property Organization), covers 125 economies, accounting for 93.2 per cent of the world's population and 98.0 per cent of the world's GDP (in current US dollars). GII ranks 125 countries/economies across the world in terms of their innovation capabilities and results.
5. The GCI rankings are drawn from a combination of publicly available hard data and the results of the Executive Opinion Survey, a comprehensive annual survey conducted by the WEF, together with its network of Partner Institutes (leading research institutes and business organizations) in the region.
6. The 2012 EPI ranks 132 countries on 22 performance indicators in ten policy categories and two overarching objectives that reflect facets of environmental health and ecosystem vitality. These indicators provide a gauge of how close countries are to environmental policy goals. The pilot trend EPI reflects changes in environmental performance over the period 2000-2010.
7. The framework constitutes the following four pillars as necessary for the realization of the KE factors in a country: an economic and institutional regime to provide incentives for the efficient use of existing and new knowledge and the flourishing of entrepreneurship; an educated and skilled population to create, share, and use knowledge well; an efficient innovation system of firms, research centers, universities, consultants and other organizations to tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new technology; and ICT to facilitate the effective creation, dissemination and processing of information.
8. The DOI is a standard tool that governments, operators, development agencies, researchers and others can use to measure the digital divide and compare ICT performance within and across countries.

References

Abdalla, I., Al-Waqfi, M., Harb, N., Hijazi, R. and Zoubeidi, T. (2010), "Labour policy and determinants of employment and wages in a developing economy with labour shortage", *LABOUR: Review of Labour Economics and Industrial Relations*, Vol. 24 No. 2, pp. 163-177.

Ahmed, A. and Al-Roubaie, A. (2012), "Building a knowledge-based economy in the Muslim world: the critical role of innovation and technological learning", *World Journal of Science, Technology and Sustainable Development*, Vol. 9 No. 2, pp. 76-98.

Ahmed, A. (2005), "Digital publishing and the new era of digital divide", *International Journal of Learning and Intellectual Capital*, Vol. 2 No. 4, pp. 321-338.

Al Awad, M. (2010), "The cost of foreign labor in the United Arab Emirates", Working paper No. 3, Institute for Social & Economic Research, Zayed University, Abu Dhabi, July, available at: www.ISER.ae (accessed November 2012).

Bachellerie, I.J. (2010), "Knowledge creation and diffusion: the role of UAE universities", Gulf Research Center (GRC), report, paper presented to the WAITRO 20th Biennial Congress: Leadership for innovation, DIT Dubai, Dubai, 13-14 October.

Bartholomew, S. (1997), "The globalization of technology: a socio-cultural perspective", in Howells, J. and Michie J. (Eds), *Technology, Innovation and Competitiveness*, Edward Elgar, Cheltenham, pp. 37-64.

Chen, D.H.C. and Dahlman, C.J. (2006), "The knowledge economy, KAM methodology and World Bank operations", Paper No. 35867, World Bank, Washington, DC.

Hijazi, R., Zoubeidi, T., Abdalla, I., Al-Waqfi, M. and Harb, N. (2008), "A study of the UAE higher education sector in light of Dubai's strategic objectives", *Journal of Economic & Administrative Sciences*, Vol. 24 No. 1, pp 68-81.

Human Development Report (2006), United Nations Development Program (NDP), published by Palgave Macmillan.

INSEAD (2011), *The Global Innovation Index 2011: Accelerating Growth and Development*, in Dutta, S. (Ed.), The Business School for the World, INSEAD, Fontainebleau, ISBN: 978-2-9522210-1-6, available at: www.globalinnovationindex.org/gii/index.html (accessed June 2012).

International Monetary Fund (IMF) (2007), "World economic outlook database", Washington, DC.

McGlennon, D. (2006), "Building research capacity in the gulf cooperation council countries: strategy, funding and engagement, UNESCO forum on higher education, research and knowledge", 29 November-1 December, available at: http://portal.unesco.org/education/es/files/51665/11634953625McGlennonEN.pdf/McGlennon-EN.pdf (accessed July 2012).

Nour, S.O.M. (2005), "Science and technology development indicators in the Arab region: a comparative study of gulf and Mediterranean Arab Countries", Discussion Paper Series No. 2005-3, United Nations University, Institute for New Technologies, Maastricht, available at: www.sciencedev.net/Docs/science%20in%20arab%20countries.pdf (accessed September 2012).

Lefrere, P. (2007), "Competing higher education futures in a globalizing world", *European Journal of Education*, Vol. 42 No. 2, pp. 201-212.

Salmi, J. (2009), *The Challenge of Establishing World-Class Universities*, World Bank, Washington, DC.

SCImago (2007), "SJR – SCImago journal & country rank", available at: www.scimagojr.com (accessed 3 February 2012).

Radwan, I. and Pellegrini, G. (2010), *Knowledge, Productivity, and Innovation in Nigeria: Creating a New Economy*, World Bank Document No. 53645, World Bank, Washington, DC.

UNDP (2002), *Arab Human Development Report: Creating Opportunities for Future Generations*, United Nations Publications, New York, NY.

UNDP (2003), *Arab Human Development Report: Building a Knowledge Society*, United Nations' Publications, New York, NY.

UNDP (2009), "Arab knowledge Report 2009: towards productive intercommunication for knowledge", joint sponsorship report of the Mohammed bin Rashid Al Maktoum Foundation (MBRF) and the United Nations Development Programme/Regional Bureau for Arab States (UNDP/RBAS), Al Ghurair Printing & Publishing House L.L.C, Dubai.

Wilson, K. (2010), "How competitive are gulf economies", presentation, Gulf Research Center (GRC), published 14 June 2010.

World Bank (1999), "World development report 1998/1999", Knowledge for Development, World Bank, Washington, DC.

World Bank (2005b), *India and the Knowledge Economy: Leveraging Strengths and Opportunities*, World Bank, Washington, DC.

World Bank (2006), *Korea as a Knowledge Economy, Evolutionary Process and Lessons Learned*, World Bank, Washington, DC.

World Bank (2012), "Knowledge economy index (KEI)", available at: http://info.worldbank.org/etools/kam2/KAM_page5.asp (accessed November 2012).

World Economic Forum (WEF) (2006-2011), *Global Competitiveness Report*, World Economic Forum, Geneva.

World Economic Forum (WEF) (2011-2012), "Global Competitiveness Report", World Economic Forum, Geneva.

World Information Society Report (WISR) (2006), "International telecommunication union (ITU), Geneva", available at: www.itu.int/osg/spu/publications/worldinformationsociety/2006/report.html (accessed December 2012).

World Information Society Report (WISR) (2007), "International telecommunication union (ITU), Geneva", available at: www.itu.int/osg/spu/publications/worldinformationsociety/2007/index.html (accessed December 2012).

Yale Centre for Environmental Law and Policy, Yale University (various years), "Environmental sustainability/performance index", Yale Centre for Environmental Law and Policy, Yale University, available at: http://www.yale.edu/esi

Zahlan, A.E. (2012), "Science and sovereignty; prospects for the Arab World", Chapter 6", Palgrave Macmillan, Center for Arab Unity Studies, July.

Zahlan, B. (2007), "Higher education, R&D, economic development, regional and global interface, UNESCO FORUM on higher education, research and knowledge", Presented at the Regional Seminar The Impact of Globalization on Higher Education and Research in the Arab States, Rabat, 24-25 May.

Further reading

United Nations (2001), *Human Development Report 2001: Making New Technologies Work for Human Development*, United Nations Development Programme Oxford University Press Inc, New York, NY.

United Nations (2010), *Technology and Innovation Report 2010*, United Nations, New York, NY.

United Nations Economic and Social Commission for Africa (UNECA) (2010), "Innovation for Africa's industrial development", E/ECA/CODIST/2/INF/4, May Addis Ababa, p. 5.

World Bank (2008), "Science, technology, and innovation: capacity building for sustainable growth and poverty reduction", report based on The Global Forum on Building Science, Technology and Innovation Capacity for Sustainable Growth and Poverty Reduction, held in Washington, DC on 13-15 February, The International Bank for Reconstruction and Development/The World Bank, Washington, DC.

World Economic Forum (2010), "The global competitiveness report 2010-2011", Geneva, Switzerland.

World Information Society Report (WISR) (2009), *Information Society Statistical Profiles Arab States*, International Telecommunication Union (ITU), Geneva, available at: www.itu.int/dms_pub/itu-d/opb/ind/D-IND-RPM.AR-2009-R1-PDF-E.pdf (accessed December 2012).

World Information Society Report (WISR) (2011), *Measuring the Information Society*, International Telecommunication Union (ITU), Geneva, available at: www.itu.int/ITU-D/ict/publications/idi/material/2011/MIS_2011_without_annex_5.pdf (accessed December 2012).

World Information Society Report (WISR) ICT (2012), *Adoption and Prospects in the Arab Region*, International Telecommunication Union (ITU), Geneva, available at: www.itu.int/dms_pub/itu-d/opb/ind/D-IND-AR-2012-PDF-E.pdf (accessed December 2012).

World Telecommunication Development Report (2003), *Access Indicators for the Information Society*, 7th ed., International Telecommunication Union (ITU), Geneva, available at: www.zitu.int/ITU-D/ict/publications/wtdr_03/index.html (accessed December 2012).

World Telecommunication/ICT Development Report (2006), *Measuring ICT for Social and Economic Development*, 8th ed., International Telecommunication Union (ITU), Geneva, available at: www.itu.int/ITU-D/ict/publications/wtdr_06/index.html (accessed December 2012).

World Telecommunication/ICT Development Report (2010), *Monitoring The Wsis Targets: A Mid-Term Review*, International Telecommunication Union (ITU), Geneva, available at: www.itu.int/ITU-/ict/publications/wtdr_10/material/WTDR2010_e_v1.pdf (accessed December 2012).

World Telecommunication Indicators (2004/2005), 2005 edition, ISBN E: 92-61-11331-1, International Telecommunication Union (ITU), Geneva, available at: www.itu.int/ITU-D/ict/publications/wti2004-05/index.html (accessed December 2012).

World Telecommunication Indicators Database (2005), *World Telecommunication Indicators Database*, 9th ed., International Telecommunication Union (ITU), Geneva, available at: www.itu.int/ITU-D/ict/Indicators Database