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Knowledge Creation and Diffusion: the Role of UAE Universities

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Abstract

Universities are central to building the innovative capacity of societies, the economy or industries alike because they provide access to basic science, the experience and knowledge of their researchers and learning opportunities to understand and adapt knowledge. Hence, exploring the structure and capabilities of the higher education institutions allows the appreciation of their contributions in the transfer of knowledge or technology from the research community to those sectors of the economy which apply that knowledge for enhanced productivity or commercial innovations. It also allows the understanding of the human efforts and resources engaged in learning, adapting or creating new knowledge for local needs and how these concepts are linked to the production, transmission and transfer of knowledge within local higher education institutions. The present paper seeks to explore the role leading universities play in the national innovation system of the United Arab Emirates (UAE) and how they support the transfer of knowledge that nurtures the overall catching-up - development - process. It provides a typology of academic research outputs and university-industry relationships that exist within the UAE and seeks to understand their contribution to the development of local industry capabilities in strategic technology fields. Comparison is made when possible between local issues (difficulties) and those seen in developed or developing countries.

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Introduction: Prominence of the Knowledge Economy

Access to scientific and technological knowledge and the ability to exploit it are globally recognized as decisive for the economic performance of countries in the competitive globalized economy.² This capacity to acquire, utilize and transform knowledge into strategies, processes and products has a direct impact on the ability of a society, an institution or an individual to innovate. So much so that what characterizes a knowledge-based economy is the extent to which production, use, and dissemination of knowledge and information are critical to economic growth and development. Indeed, the availability of technology and know-how to convert resources into products; research and development (R&D) and innovative effort; and development of human capital through education promote the productivity of the economy and its growth. Hence, linking science to development has served as a base for science policies in many countries, where specialized institutions related to science and technology acquisition, diffusion, absorption and creation - such as universities, R&D laboratories and public policies - have been created to support the transfer of knowledge that nurtures the overall development process.

Knowledge should not be considered here as a universally available commodity or a free public good. Neither should knowledge transfer be considered a simple commercial and legal transaction between agents. As Wolf emphasizes, "In contrast to data and information, that can be generated and transmitted through the enhanced power of Information and Communication Technologies (ICT), knowledge involves a critical degree of discernment, or rather the ability to distinguish and understand those pieces of knowledge which may be technologically or economically valuable. Individuals and organizations require a complex set of skills and must expend considerable resources to absorb, understand and use information. The latter only becomes accessible knowledge - and therefore valuable and useful - when potential users have access to its underlying tacit dimension, as well as the skills and capabilities to make sense of it ... This emphasis on the skills and capabilities required to absorb knowledge underscores the centrality of learning for the innovative process".³

At the industrial level, the need to draw upon a diversity of knowledge sources, the increasing costs of Research and Development (R&D), and the imperatives for firms to continuously design and develop breakthrough products and processes to maintain a competitive edge, are all driving factors for enhancing learning processes. In fact, it may be appropriate to describe the emerging paradigm as that of a "Learning economy", rather than a knowledge-based one.⁴ Accordingly, a country's access to scientific and technological knowledge and the ability to exploit it are affected by this capacity for learning, building new competencies and acquiring new skills.

Such a capacity cannot be better nationally supported and represented than by universities. In particular, for their access to basic science, the experience and tacit knowledge of their researchers and the learning opportunities they offer their graduates to understand and

² Organization of Economic Cooperation and Development (OECD), "The Second European Report on S&T Indicators 1997", Luxembourg European Commission, p. ix

³ David A. Wolfe, "Knowledge and Innovation: A discussion Paper", Munk Centre for International Studies, University of Toronto (Ontario 2006), p.4

⁴ Ibid., p.5

adapt knowledge, universities are central to building the innovative capacity of societies, the economy or industries alike. Hence, exploring the structure and capabilities of the higher education institutions allows the appreciation of their contributions in the transfer of knowledge or technology from the research community to those sectors of the economy which apply that knowledge for enhanced productivity or commercial innovations. It allows the understanding of the human efforts and resources engaged in learning, adapting or creating new knowledge for local needs and how these concepts are linked to the production, transmission and transfer of knowledge within local higher education institutions.

An eminent example for the Learning Economy paradigm and its innovation-inducing character is Korea's industrializing experience. Since the 1960s, Korea has transformed itself from a dependent client state into an independent economic power, through adapting models of research and technical education from industrialized to the industrializing countries. The rapid pace of economic growth and the development of heavy and light industries needed well-trained scientists and engineers and called for increasing enrolment in science and engineering fields, which the Korean universities seemed poorly prepared to deliver. At the undergraduate level, Korea turned out some 5,000 students in science and engineering each year, but most programs had simply not kept pace with industry. The multiple weaknesses of the domestic university system led the Korean government to adopt policies aimed at improving the quantity and quality of graduate level education, including the establishment in 1971 of the Korea Advanced Institute of Science (KAIS). The latter was exclusively committed to science and engineering training and research and was intended to supply highly-trained graduates to both public research laboratories, such as the Korea Institute of Science and Technology (KIST) established in 1966, and industrial firms. KAIS' charter called for graduates "able to adapt the world's science and technology to Korean processes, methods, and materials, to create distinctive designs and products for Korean Markets, both domestic and foreign, and to make Korean products fully competitive in international trade in both quality and cost". In 25 years, KAIS awarded 2,647 doctoral, 9,566 masters, and 3,108 bachelor's degrees and completed sponsored research contracts worth \$200 million. In what may be described as a spill-over effect, other Korean universities emulated KAIS' research and teaching program. Seoul National University dramatically strengthened its colleges of natural science and engineering in the mid 1970s and began encouraging corporate research partnerships of its own in the mid 1990s.⁵

Based on historical evidence, Mazzoleni finds that - in different countries whose development during the nineteenth and twentieth centuries represent clear instances of catching up with economic leaders of their time - the role of academic institutions changed considerably during their process of economic and technological development. For example, against a clear separation between theoretical scientific research at German universities during the nineteenth century - from which technology was excluded as a subject for teaching or research - and applied research conducted on industrial needs in the Technische

⁵ On the role of KAIS in the industrialization of Korea see Kim Dong-Won and Stuart W. Leslie, "Winning Markets or Winning Nobel Prizes? KAIST and the Challenges of Late Industrialization", OSIRIs, 2nd Series, Vol., 13, Beyond Joseph Needham: Science, Technology, and Medicine in East and Southeast Asia (1998), pp. 154-185. Esp. pp. 157, 167, 171 and 181; On the general role of academic institutions in the catching up processes, see Roberto Mazzoleni, "Catching Up and Academic Institutions: A Comparative Study of Past National Experiences", Journal of Development Studies, Vol. 44, No. 5, (May 2008) pp. 678-700. Esp. pp. 689-690



Hochschulen, a convergence took place in such a fashion that the German chemical industry in the second half of the century owed a great deal to the strength of the academic training in chemistry at German universities and to the abundant supply of chemists who were accustomed to laboratory research of the kind that became common among the leading chemical firms of the period.⁶

More generally, Mazzolenni concludes:

There seems to be little doubt that the diffusion of advanced British techniques to continental Europe and the US was primarily stimulated by the migration of skilled personnel to these countries. But we believe that processes of knowledge creation and transmission associated with academic institutions complemented this mechanism. First, the absorptive capacity of the catching up economies was enhanced by the development of a variety of educational institutions focused on the training of scientists and engineers. Second, the role of formal training increased over the course of the century as a result of widening and deepening interactions between scientific knowledge and technology on the one hand, and of the adaptation of educational curricula at universities and technical institutes of higher education taking place in response to among other things, the development of indigenous industries. Third, the development of the educational systems in the catching up countries opened up a variety of patterns of knowledge diffusion. These included cross-border flows of students, teachers, and graduates whose academic and professional experiences had matured abroad.⁷

In the light of this, we will try in the following sections to articulate the state of the Higher Education output in the context of the United Arab Emirates' (UAE) economic and industrial growth, to analyze its role in knowledge creation, transmission and transfer during the catching-up process with more advanced countries and within the context of global competitiveness.

This paper will try to delineate the level and capacity of R&D in the productive sectors of the UAE economy in terms of human, scientific and technological resources. It will focus on paralleling the development of natural resources and economic markets in the UAE with its pool of skilled personnel and talents.

It is important to emphasize that the entire population of the UAE, nationals and non nationals, is at the core of the development process of the country, participating in the growth of its economy and the creation of its wealth. Nationals and non-nationals are the economic agents that together impact production, consumption, accumulation of knowledge and creativity within public and private socio-economic institutions. Hence this study, in interfacing issues linked to social and economic growth, industrial diversification, science and technology diffusion, and supporting mechanisms through which universities nurture the development process, will not differentiate between national and non-nationals. Furthermore, the paper is mainly a status quo report of the state of knowledge diffusion in the UAE which can then be used to work on policy solutions.

⁶ Roberto Mazzoleni, "Catching Up and Academic Institutions: A Comparative Study of Past National Experiences", *Journal of Development Studies*, Vol. 44, No. 5, (May 2008). pp. 679-683

⁷ *Ibid.*, p. 688

I. Socio-economic Profile of the UAE

The World Bank classification of economies indicates that the UAE is in the high income group. The UAE registers a good performance in terms of the Human Development Index (HDI) components and other socio-economic indicators. In 2005, the HDI for the UAE attained the value of 0.87 which is indicative of a high standard of human and economic development. This index is based on three indicators: Longevity, as measured by life expectancy at birth; Educational Attainment, as measured by a combination of adult literacy rate and the combined gross secondary and tertiary enrolment ratios; and Standard of Living, as measured by Gross Domestic Product (GDP) per capita (see Table I)

Table I: UAE Human Development - Demographic and Socio-Economic indicators

	Population (millions) (1)	GDP (Million US \$) (a)	GDP per Capita (PPP) US \$ (b)	Human Development Index (c)	Literacy Rate (%) (d)	Estimated educational level of people aged 25-50 (e) (weighted Average)	Educational level index (%) (e)	Education and Human Resources Index (f)	Gross enrolment ratio in Tertiary education (%) (f)
1995	na	45,000	17,755	0.83	73	na	na	4.27	10.9
2000	2.9	70,246	20,530	0.84	77	na	na	3.92	17.75
2005	4.1	132,202	34,600	0.87	89	3.31	67	4.78	na
2007	4.5	na	na	na	90	na	na	4.90	22.85

Sources:

(1) Ministry of Economy - Central Statistic Department / Actual and estimated Population, Labor force and Employed 1975 - 2009

(a) GOIC Gulf Statistical Profile (2007)

(b) PPP: Purchasing Power Parity / For 1995: UNESCO Science Report (2005) / For 2000 : UNDP Human Development Report (2003) / For 2005: The UAE in Figures, National Bureau of Statistics 2009

(c) World Bank Knowledge Assessment Methodology (KAM) - http://info.worldbank.org/etools/kam2/KAM_page2.asp / UNDP Human Development Report 2007/2008, table 1

(d) For 2005: Arab Knowledge Report table 3.5 / for 2007: World Bank KAM

(e) Arab Knowledge report, 2009 / Table 28

(f) World Bank Knowledge Assessment Methodology (KAM): http://info.worldbank.org/etools/kam2/KAM_page2.asp

Average GDP per capita as well as literacy rate are also classified as high. The improvement of these indicators has been continuous despite increases in the migrant population. In particular, the UAE has witnessed, in a relatively short time, a massive expansion of its education system offering access to basic education to almost all school-age children. This in part was made possible through urbanization and decentralization of the social and economic life in the seven emirates.

According to the Arab Knowledge Report, the UAE total population has a critical mass of adults who possess a relatively sufficient knowledge capital to enable them to participate in the knowledge society. The estimated educational level of people aged 25-50 in the UAE, which accounts for the generations of primary vital forces in society and the largest



numbers of adults - has a weighted average value of 3.31.⁸ This corresponds to Literacy and School life expectancy rates of respectively 90% and 45% - eight years of study - or an average of 67% as an educational level index.⁹

If we however look at the World Bank Education and Human Resources index, we find that, despite progress, UAE's population has fallen beneath the global average for the last 15 years (4.9 in 2007 over a maximum of 10), which reveals a rather different aspect of its preparedness for the knowledge based economy. This index is based on three variables: Adult Literacy rate, Secondary Enrolment, and Tertiary Enrolment. Its value falls on a scale of 0-10. The top 10 per cent of states score in the range 9-10, the next highest 10 per cent of states score in the range 8-9 and so on. For this index, the top of the list (Denmark) scored 9.78, South Korea Scored 8.01 and GCC country Saudi Arabia 4.89 in 2007.¹⁰ One is inclined to wonder whether these indexes are conclusive - or coherent enough - in the case of the UAE's population, for which literacy and education were and still are achieved in different languages and curricula and where nationals account for a mere 15% of total population. Indeed, this disparity of backgrounds can make participation in the knowledge society culturally and economically fragmented and eventually hard to capture.

II. UAE's Labor Force Skills and Education

Industrial diversification away from oil and gas resources, technology transfer and human development are considered by the UAE public and private sectors as the main path to sustainable growth and development. The rapid socio-economic growth that the UAE has witnessed has increased demand for a wide variety of mechanical devices from construction equipment, water treatment plants, petrochemical, plastics and other heavy industry, transportation systems and technologies, to oil and gas exploration, production and refining. However, to cope with such a program and pace of development, the country has tapped into global pools of both low and high skilled labor to provide most of its projects and institutions with the needed workforce, from elementary occupations and machine operators, to teachers, physicians, engineers and scientists.

⁸ Values of this indicator are to be interpreted as follows: 1 = literacy; 2 = completion of primary education; 3 = completion of the upper stage of basic or intermediate education; 4 = completion of the upper stage of secondary education; 5 = completion of a bachelor's degree. Arab Knowledge Report 2009, towards Productive Intercommunication for Knowledge, Mohammed bin Rashid Al Maktoum Foundation (MBRF) and the United Nations Development Programme/ Regional Bureau for Arab States (UNDP/RBAS), (Dubai 2009). pp. 119-120.

⁹ "The scale consists of six grades, each consisting of 16.66 per cent of the total. Thus the highest grade (from 84 per cent to 100 per cent) is excellent in terms of the ability to participate in the knowledge society. This is equivalent to the level attained by advanced industrialized countries, which is a literacy rate above 95 per cent and an average school life expectancy of no less than 13 out of 18 possible years. The second grade acceptable level (between 67 per cent and 83 per cent) is good and the third (between 50 per cent and 66 per cent) is the lowest acceptable level. Grades lower than these point to various degrees of inability to participate in the knowledge" in "Arab Knowledge Report 2009 Towards Productive Intercommunication for Knowledge", op. cit., note 82, p.120

¹⁰ The low value of this index for the UAE could be explained by its particularly low gross enrolment ratio in tertiary education (in 2007 the UAE score for this indicator was 22.8%, while for Denmark it was 80%, Korea 95%, and Saudi Arabia 30%) in the World Bank Knowledge Assessment Methodology (KAM) http://info.worldbank.org/etools/kam2/KAM_page5.asp and http://info.worldbank.org/etools/kam2/KAM_page2.asp. According to the Arab Knowledge Report 2009 the apparent disinclination of males to pursue tertiary education in the UAE could partially account for its low ranking in tertiary education enrolment. "Arab Knowledge Report 2009", op .cit., p. 108

According to the Ministry of Economy, in 2005 the UAE's labor force was approximately 2.56 million, of which 17% were employed as professionals and technicians. The total number of these professionals has almost doubled in 2008, mounting to approximately 838,000, which represented 27.5% of the related total labor force.¹¹ They were found throughout different economic and industrial sectors as a reflection of the strategic shift to a diversified and skill-based economy in the UAE. According to the International Standard Classification of Occupation, Professionals and Technicians comprise professionals and technicians in the Physical, Mathematical and Engineering sciences, Life and Health Sciences, Tertiary, Secondary and Primary teaching occupations, and Business, Legal and Social Sciences. So, if we deduce the total number of teaching staff in the UAE from these numbers, correspondingly we are left with 394,000 for 2005 and 798,000 for 2008 as the estimated numbers of Professional and Technical workers in all economic sectors excluding Education.¹²

Table II: UAE's Labor Force – Skills and Education

	Labor Force (15 years +) (1)	Employed professionals, technicians and associate professionals (1)	Employed professionals, technicians and associate professionals, excluding Education (1)	Employed holding tertiary education – University and above university (1)	Crude employment rate of employed holding tertiary education (1)	Gross enrolment ratio in tertiary education (2)	Global ranking of UAE's secondary enrolment rate (3)	Global ranking of UAE's tertiary enrolment rate (3)
2005	2,559,668	437,506	394,000	407,314	na	na	na	na
2008	3,043,000	837,980	798,000	na	79.5%	23%	50 th	81 st

Sources:

(1) Ministry of Economy – Central Department of Statistics - Population Census of 2005 and the Labor Force Survey of 2008

(2) UNESCO Statistics Institute– Global Education Digest, 2009

(3) World Economic Forum – The Global Competitiveness Report 2009-2010

In a classification of labor per education status, it was found that, for 2005, the total number of employed holding tertiary education (University and above University educational level) represented 15.9% of the related total labor force. The corresponding figure for 2008 is not available. However, it is important to note that according to the Labor Force Survey of the same year - the crude employment rate for the population holding a Tertiary education was 79.5%, the highest among all categories (Primary, Secondary and Tertiary education levels), showing that this category of highly skilled personnel (HSP) is less exposed to unemployment than any other in the UAE.¹³

¹¹ Most comprehensive statistics on the UAE Labor are those from the Population Census of 2005 and the Labor Force Survey of 2008 of the UAE Ministry of Economy. Ministry of Economy - Economic and Statistic Reports in <http://www.economy.ae/English/EconomicAndStatisticReports/Pages/default.aspx>

¹² On statistics on Education see National Bureau of Statistics, "The UAE in Figures 2009"; on International Standard Classification of Occupation see <http://laborsta.ilo.org/applv8/data/isco88e.html>.

¹³ Ministry of Economy - Central Department of Statistics - Labour Force Survey 2008, op. cit., Table 3/50 "Unemployment Rate By Emirate and Educational Status"

Nevertheless, to achieve its vision of knowledge-based economy, the UAE will require bigger numbers of HSP to match the specific needs of a technology-based industry, ensure a proper and efficient usage of imported technologies and perform the necessary R&D-related activities, would the country wish to promote the development of indigenous technological capacity. For instance, when comparing attained and required qualifications in the Chemical and Metal industries in the UAE in 2002, it has been found that there was serious mismatch for low and medium skilled workers between their educational level and the required skills in their jobs (71% to 75% for Metal and 60% to 69% for Chemicals). This mismatch drops to around 29% for the highly skilled personnel, showing better adequacy to jobs in technology-based industries, which naturally can enhance productivity and support technology absorption at the firm level.¹⁴

To put things into perspective, in 2005 the share of labor force with tertiary education level in South Korea reached 32.3 % - thus amounting to a total number of 7.66 million - versus 15.9% or 407,300 the same year in the UAE.¹⁵ For the last 40 years, Korea has progressively built a capacity of “trained minds and hands” to support labor-intensive light manufacturing industries in the 1960s, capital-intensive heavy industries in 1970s, or knowledge intensive high-technology industries in the 1980s and beyond. Such a strategy of learning, adapting and accumulating technical know-how fostered transfer of technology to and ultimately competitiveness of the Korean companies. More recently, as a challenge to its competitiveness and to keep ahead of newly industrializing nations such as China - offering significantly lower wages than Korea - the latter is still training more and better scientists and engineers to gain a comparative advantage in human capital.¹⁶

According to a survey of business leaders concerning the many factors that affect the competitive landscape of the UAE, the second most problematic factor for doing business after “Access to Financing” was found to be the “Inadequately Educated Workforce”. In parallel with this executive opinion survey, hard data-based indicators of the Global Competitiveness Index (GCI) 2009-2010 point to weak tertiary and secondary enrollment rates for which the UAE ranked 81 and 50th respectively.¹⁷ Table I and II indicate that Gross enrolment ratio in Tertiary Education varied from 10.9% to a maximum of 23% between 1995 and 2008 respectively.

It is thus evident that critical efforts are still needed to raise educational attainments, improve skills of the labor force and enhance productivity in UAE enterprises.¹⁸ Moreover, knowledge transfer and technology absorption at the firm level require bigger numbers

¹⁴ Joan Muysken and Samia Nour, “Deficiencies in Education and Poor Prospects for Economic Growth in the Gulf Countries: The Case of the UAE”, *Journal of Development Studies*, Vol. 42, No. 6, pp. 957-980.

¹⁵ International Labour Office (ILO) database: <http://laborsta.ilo.org/applv8/data/c1e.html> . Interestingly when we look at the total number of employed as Professionals and Technicians in the Korean labor force we find 4.2 millions, which is less than the number of tertiary educated people in Korea. Quite the opposite was happening in the UAE in 2005.

¹⁶ On the emergence of Korea as an industrialized country see “Winning Markets or Winning Nobel Prizes? KAIST and the Challenges of Late Industrialization”, op. cit.; for the origin of the expression “trained minds and hands”, *Ibid.*, p181

¹⁷ Klaus Schwab ed., “The Global Competitiveness Report 2009-2010”, World Economic Forum (Geneva, Switzerland 2009), p. 317. For these indicators Korea’ scores were 1 and 31 respectively. On the indicators “Extent of staff training” and “Availability of scientists and engineers”, UAE and Korea rates were surprisingly close: the UAE ranking 30th and 28th, and Korea 25th and 29th respectively. This invites to a careful comparison of such measures; we shall see from next sections that the mid and high-technology manufacturing needs of these countries in terms of capabilities and know-how are incomparable.

¹⁸ 70 per cent of the workforce is in low-value occupations such as construction and the service industry, see The National, “Billions invested into university research” by Melanie Swan and Kathryn Lewis June 10 2010; in <http://www.thenational.ae/apps/pbcs.dll/article?AID=/20100610/NATIONAL/100619985/1010>

and continuous availability of workers with higher educational level to allow accumulation of experience and consequently the formation of insights and skills (tacit knowledge) that become embedded in the procedures of the work place.¹⁹

III. Knowledge Transmission and Human Development Higher Education Output

The International Standard Classification of Occupation and the International Standard Classification of Education (ISCED), both used globally in the classification of the labor force, and used in the UAE census and labor survey in particular, do not provide us with specific information on the Science and Engineering (S&E) workforce by occupation, degree or field of activity. An independent effort is usually undertaken by individual countries to assess their capacity in S&E skills and activities in terms of the number of workers in S&E occupations, their distribution throughout the industry, whether Research and Development (R&D) is a prominent activity for the S&E workforce and eventually how S&E degrees are distributed in the R&D workforce. Such a survey does not exist for the UAE.

Hence, to measure the academic output in terms of highly skilled personnel (HSP), one can consider the number of bachelor's and Master's degrees awarded in S&E fields or the number of S&E doctorates.

The UAE has worked on restructuring and expanding its higher education system to increase its capacity and make it more responsive to labor market needs and develop human resources. The Higher Education (HE) sector has witnessed a massive expansion since 1977, the year of the establishment of the UAE's first university - the University of the United Arab Emirates (UAEU). This was followed by the setting-up of the Higher Colleges of Technology (HCT) in 1988 and Zayed University (ZU) in 1998, as publicly-owned higher education institution. Private tertiary education has also seen an impressive growth since 1993, the year of the establishment of the first private University in the country. In 2008, the number of colleges and universities licensed by the Ministry of Higher Education and Scientific Research (MHESR) - including the publicly-owned UAEU, HCT and ZU - reached the impressive number of 58.

However, public expenditure on tertiary educational institutions and administrations was limited to 0.4% of the Gross Domestic Product in the UAE in 2004. For educational and demographic reasons, public higher education system could not absorb all candidates and public spending could not be increased sufficiently, which led to the political choice of partly privatizing the cost of Higher education. As a consequence, the share of the private universities and colleges in the awarded degrees in the UAE grew from 26.9% in 2001 to 54.6% in 2006. In 2007, 58% of the total tertiary students (77 thousand) were enrolled in private universities.²⁰

¹⁹ "Knowledge and Innovation: A discussion Paper", op. cit., p. 3

²⁰ On tertiary education statistics, see UNESCO Statistics Institute, "Global Education Digest 2008 Comparing Education Statistics around the World". On the share of private universities see Rafiq Hijazi, Taoufik Zoubeidi, Ibrahim Abdalla, Mohamed Al-Waqfi, Nasri Harb, "A study of the UAE Higher Education Sector in Light of Dubai's Strategic Objectives", Journal of Economic & Administrative Sciences, Vol. 24, No 1 (2008) pp. 68-81, and Ramsus Gjdso Bertelsen, "Private Higher Education in the GCC:



Table III. a. – UAE's Tertiary Education Graduates

	Total number of tertiary education graduates	Number of graduates in Science and Technology fields	Number of graduates in Science	Number of graduates in Engineering, Manufacturing and Construction	Number of graduates in Social Science, Business and Law	Number of graduates in Education	Number of graduates in Health and Welfare
2007	13,000	4,290	3,055	1,235	4,550	1,560	650

Source: UNESCO Statistics Institute– Global Education Digest, 2008

Yet, despite the increasing number of higher education institutions, it is curious to notice that the total number of students enrolled in the UAE universities, which approximately attained 85,000 in 2004/2005 decreased to 79,950 in 2007/2008. Similarly, after a peak of 15,831 in the total number of HE graduates in 2006, this number decreased to 13,700 (13,000 according to UNESCO) and 14,992 in 2007 and 2008 respectively.²¹ Such a decline in enrolment and graduation figures may be linked to more drastic admission standards and criteria or to abandonment of studies before completion (the current rate of university drop-outs is 20%).²²

In 2010, it is estimated that 26 public and private universities and colleges in the UAE offer degrees in Science and Engineering, most of them leading to two to three years Diploma or four years bachelor degrees in diverse S&E majors like Civil, Mechanical, Electrical, Information and Communication Technologies, Computing, Electronic, Energy, Aviation, BioMedical, Pharmacy, Health Sciences, Medicine, Agriculture and Environment.²³

Scarcity of Scientists and Engineers

UNESCO's Institute of Statistics carried out a Science & Technology survey in 2008 in 149 developing countries to compile valuable statistics about the total number of R&D scientists and engineers, their distribution by sector of employment, the number of researchers per million inhabitants, or the Gross Domestic Expenditure on R&D (GERD). Unfortunately, all these indicators are not available for the UAE.²⁴ This naturally makes it difficult to estimate accurately the R&D capacity of its economic system.²⁵

Best Practices in Governance, Quality Assurance and Funding", Belfer Center for Science and International Affairs (2009)

²¹ "The UAE in Figures 2009", op., cit. These figures are slightly different from UNESCO figures for 2007, see UNESCO Statistics Institute, "Global Education Digest 2008 Comparing Education Statistics Around the World" (2008)

²² Officials from the Abu Dhabi Education Council to the National, in The national, "Billions invested into university research" by Melanie Swan and Kathryn Lewis June 10th 2010; in <http://www.thenational.ae/apps/pbcs.dll/article?AID=/20100610/NATIONAL/100619985/1010>

²³ UAE Education Guide was launched in August 18, 2010 but not yet made available while writing this article <http://www.wam.org.ae/servlet/Satellite?c=WamLocEnews&cid=1278056001048&p=1135099400124&pagename=WAM%2FWamLocEnews%2FW-T-LEN-FullNews>

²⁴ The UNESCO Institute of Statistics, Science and Technology Survey 2008 in http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx?IF_ActivePath=P.54&IF_Language=eng

²⁵ The figures we have indicate that there were 107 Full Time Equivalent researchers holding a doctorate or a master degree in the UAE in 1996, 45% of which were employed in the public sector, 55% in universities and 0% in the private sector. In 2009 there were 26,802 Employed holding a Doctorate or a Master degree in Dubai; in UNESCO Science Report 2005 p. 168 and Dubai Statistics Center - Labor Force Survey, 2009. With 10.3 millions of R&D spending in 1996, the UAE GERD was likely to be 0.02%, see UN Economic and Social Commission for Western Asia (UN-ESCWA) "New Indicators for Science, Technology and Innovation in the Knowledge-based Society" "September 2003. For more recent values see Kenneth Wilson, "Presentation to INCONET - GCC Programme", Induction event in Athens June 2010 : "The GERD is likely to be below 0.3% in each Gulf state except in KSA where it is likely to be around 0.5%"

For 2007, the tertiary education output in Science, Engineering and Health was around 23% (3,055), 9% (1,235) and 5% (650), respectively.²⁶ If we look at the health sector in the UAE, it was growing at a Compound Annual Growth Rate (CAGR) of 15%, thus creating around 1,900 new positions for physicians and dentists alone for the same year (estimation based on Table III. b. Scarcity of Health and Welfare Graduates). As one can see, UAE universities with all their outputs in Health Sciences were unable to cater to the needs of its sector in 2007. It should have grown 4.5 times faster. This points to a glaring gap between the social and economic needs of the UAE on the one hand and its universities output on the other.

Table III. b. – Scarcity of Health and Welfare Graduates

	Total number of Physicians	Total number of Dentists	Total
2005	8,295	1,355	9,650
2007	10,123	2,455	12,568

Source: United Arab Emirates, National Bureau of Statistics the UAE in figures, 2009

In 2005, the whole manufacturing sector employed approximately 200,000 people, of which it is estimated that around 30 percent were in professional and technical occupations, thus amounting to 60,000 employees with mid to high skill jobs (values were estimated based on the MoE's 2005 and 2008 labor statistics). If we assume that Professionals and Technicians should all have tertiary education, and that at least two thirds are scientists and engineers, we can suppose that 20% of the manufacturing labor force are estimated to be engineers and technicians.

Between 2000 and 2006, the manufacturing sector had a Compound Annual Growth Rate (CAGR) of 19%. Accordingly, the average number of new Scientists and Engineers occupations needed was estimated to be 7,600 for 2006 and 9,050 for 2007 (19% annual growth in new occupations). However, the total number of "Science and Engineering" graduates of UAE universities was approximately 4,300 in 2007, hence short of 4,750 versus the needs of the manufacturing sector (which are at least twice as high as actual university output in scientists and engineers). The expansion of the manufacturing industries in the UAE is clearly outpacing the capacity of its universities to train engineers and technicians in sufficient numbers. To only meet the annual job demand in the manufacturing sector, universities in the UAE should have grown their output by an extra 110.5%, which is six times that of the manufacturing CAGR. Until that happens, shortages in homegrown engineers and scientists will become even bigger year after year, assuming a continuous growth in the manufacturing sector.

More generally, in the years 2003, 2004 and 2005, the UAE Ministry of Labor issued 42,262; 51,189 and 90,737 work permits, respectively. The total numbers of graduates from UAE-based universities and colleges represented 26%, 23% and 13% of these figures respectively.²⁷

²⁶ Science: life sciences; physical sciences; mathematics and statistics; computer sciences; Engineering: Engineering and Engineering trades, manufacturing and processing; architecture and building; Health and Welfare: Medicine; medical services; nursing; dental services; social care; social work; UNESCO Statistics Institute, "Global Education Digest 2008 Comparing Education Statistics Around the World", op., cit.

²⁷ "A study of the UAE Higher Education Sector in Light of Dubai's Strategic Objectives", op., cit., p.75

In other words, the UAE universities are far from producing enough graduates to meet the needs of the growth of its economy in general and of its S&T based industries in particular.

Table III. c. – Evolution of Graduates as percentage of work permits issued

	Number of work permits issued by UAE MoL	Of which for Graduates of UAE universities and colleges	Balance
2003	42,262	26%	74%
2004	51,189	23%	77%
2005	90,737	13%	87%

Source: Rafiq Hijazi, Taoufik Zoubeidi, Ibrahim Abdalla, Mohamed Al-Waqfi, Nasri Harb (2008)

Nevertheless, the competitiveness of the UAE HE system graduates, in local and global economies, is incumbent on the availability and quality of education and training opportunities that are offered. To attract students, most public and private HE institutions in the UAE collaborate with foreign universities and/or seek accreditation from North American Education Accreditation agencies. They also keep close ties with scientific universities and institutes all over the world to stay informed about the latest education technologies, enhance research efforts undertaken by their faculty, or provide top performing students with possibilities to continue their education or training abroad.

However, the mission and quality of the HE system cannot be achieved solely through for-profit investment in or competition among universities and programs. In particular, alignment with the needs of industry and government developmental strategies in terms of required skills and qualification should be ensured and regulated by the appropriate public authorities.

For the present, local HE capacity and programs still fall short of answering the local socio-economic need for human development and economic diversification; they do not provide the economy with the necessary number of highly-skilled personnel or R&D workforce. Opportunities for postgraduate studies in scientific fields in the UAE are embryonic, S&E master degrees are limited and doctoral studies are still non-existent.²⁸ Hence, both S&E graduate and postgraduate educations present quantitative and qualitative challenges for the UAE to establish a knowledge-based economy. In the context of the global race for talents, where knowledge-based industries in many countries are driving global demand for human resources in science and technology, the availability of such a pool of HSP will be a critical differentiating element of development.²⁹

IV. Transferring Exogenous Technology

In 2010, the World Economic Forum Report on the Global Competitiveness Index (WEF-GCI) considered that the UAE had in place the underlying fundamentals of a competitive economy. The country ranked 11th for “Quality of overall infrastructure” and 17th for

²⁸ The University of Wollongong in Dubai (UOWD) will offer a Doctorate of Business Administration (DBA) and PhD programs accredited by Ministry of Higher Education and Scientific Research (MOHESR) starting from October 2010. UOWD is the first nationally accredited University in the UAE to offer a Doctoral program, and is per September 2010 the only one.

²⁹ According to the Global Competitiveness Index (GCI) Report 2009-2010, The UAE ranked 28th in 2009 for the indicator “availability of scientists and engineers” see GCI Report 2009-2010, op. cit., p.317

“Technological readiness”, which gives the country a competitive advantage. Together with the ICT index components, the “Technological readiness” indicator of the GCI takes into account the “availability of latest technologies”, the “firm-level technology absorption” and “FDI and technology transfer”, variables for which the UAE ranked 8th, 4th and 6th, respectively.³⁰

Nevertheless, in addition to the GCI variables, one should consider the size of technology imports and exports, as well as the share of technology-based industries in the labor force to gain a larger idea of the level of technology transfer in the UAE economy.

Indeed, the size of imports of technology products (selected sections here are: Chemical, Machinery, Equipment and Manufactured products, as per United Nations Standard International Trade Classification - SITC) amounted to 56,914 million US\$ for 2005, which represented 67.4% of total imports. These figures increased to 67,422 million US\$ and 69%, respectively for 2006, clearly showing a high and increasing demand for foreign technology in the UAE (See Table IV Indicators in the UAE).

Table IV: Technology Imports and Exports in the UAE

	Exports of Chemical, Machinery, Equipment and Manufactured products in billion US\$ (1)	Imports of Chemical, Machinery, Equipment and Manufactured products in billion US\$ (1)	Trade balance of Chemical, Machinery, Equipment and Manufactured products in billion US\$ (1)	Trade balance as % of trade surplus of Mineral Fuel and Crude Oil (1)	High-technology exports as % of Manufactured exports (2)
2005	27.2	56.9	-29.7	71%	1.8%
2006	23.6	66.5	-42.9	63%	1.2%

Sources:

(1) Calculated from GOIC Gulf statistical profile (2007)

(2) World Bank data

If we look at the size of exports for those same sectors of the industry, we find that Chemical, Machinery, Equipment and Manufactured products amounted to 27,166 millions US\$ in 2005, but slightly decreased to 23,611 millions US\$ in 2006, translating into 23.16 % and 16.57 % of total UAE exports for the respective years. These UAE exports figures include technology re-exports, hence showing only a portion of these exports are really produced in the UAE.

Overall the trade deficit - exports minus imports - for these industries amounted to a staggering 29.7 billion US\$ in 2005, corresponding to 22.5% of the UAE GDP. This deficit increased to 42.9 billion US\$, i.e. 27% of GDP in 2006, which indicates a negative trend in technology transfer:

1) The domestic demand for technology products and equipment is increasing.

³⁰ “The Global Competitiveness Report 2009-2010”, op., cit., pp. 36 and. 317. The ICT index value is calculated from three key indicators: number of telephone lines per thousand of the population, number of computers per thousand of the population, and number of internet users per thousand of the population. World Bank KAM in http://info.worldbank.org/etools/kam2/KAM_page6.asp



2) The domestic production of technology products and equipment is insufficient to cater to domestic needs. As a consequence, the country's demand for and dependency on foreign technology accelerates.

3) This dependency creates a huge negative impact on the national balance of trade.³¹

Indeed, if one excludes the oil surplus of 41.6 billion US\$ in 2005 and 67.5 billion US\$ in 2006 from the national balance of trade of the respective years, the latter would have shown a deficit of -8.8 billion US\$ in 2005 and -22.8 billion US\$ in 2006. Furthermore, the increase in the trade deficit of this selected trade balance (totaling -14 billion US\$ from 2005 to 2006) is almost entirely driven by the increase in trade deficit in the Technology industries (totaling -13.2 billion US\$ from 2005 to 2006).

Another indicator of science and technology at a country level is High-technology exports as a percentage of all manufactured exports. High-technology exports are classified in the World Bank database as products with high Research & Development (R&D) intensity, such as in Aerospace, Computers, Pharmaceuticals, Scientific instruments, and Electrical machinery. For this indicator the UAE scored 1.8%, 1.2% and 3.2% for 2005, 2007 and 2008, respectively. The numbers for 2005 and 2007 confirm our previous conclusions but 2008 shows a slight reversing trend. Nevertheless, such a performance remains trivial in comparison with Korea's. The latter scored 32.3%, 32.0% and 33.4% for 2005, 2006 and 2007, respectively for high-technology exports as percentage of its total manufactured exports.³²

So, despite UAE expenditure and volume growth in technology industries, these still create a huge deficit in the trade balance. In particular, when looking at high-technology products, one can see that little technology transfer is happening. In this regard, the UAE economy has not yet become an economy based on technology development nor is it actually evolving in this direction.

It is instructive at this level of our analysis to briefly consider the Korean experience. By 1961, Korea had spent some 100 million US\$ on foreign licensing, training and fees, but to compete with foreign firms it needed access to foreign know-how. During the 1960s, Korea encouraged cooperative ventures with foreign firms as a source of capital, technology and experience, but very quickly realized that, even though Foreign Direct Investment and Licenses could provide Korean industries with know-how and access to international markets, they could also create a new kind of dependency. Firms owned by foreign entities accounted for high shares in manufacturing exports especially in key industries like machinery, metal products, electric and electronic components. Heavy imports of advanced technologies that Korean firms could not manufacture themselves - like electronics and electronic components - meant that Korea still run-up substantial trade deficits.

³¹ The national Balance of Trade amounted to 32,844 millions \$ in 2005 and 44,656 Millions \$ in 2006, figures calculated from data published by Gulf Organization for Industrial Consulting (GOIC) "Gulf Statistical Profile"(2007)

³² Regionally, KSA did not perform better than the UAE (KSA figures are 0.6%; 0.9%; 0.6% for 2005, 2006 and 2007 respectively, data available in World Bank database in <http://data.worldbank.org/indicator/TX.VAL.TECH.MF.ZS>

In 1967, Korea was spending less than 0.5% of its GDP on R&D. Its universities awarded several thousand undergraduate degrees in Science and Engineering, but the best students went abroad. In one important respect, the country was starting from scratch. So to strengthen its technological infrastructure, moving from labor-intensive to a knowledge-intensive economy, Korea realized that it needed to increase the supply of researchers and the demand for research itself in the same time. Even when foreign technology was cheaper in the short run, R&D was considered to be a profitable long-term investment and the best road to self sufficiency.³³

Subsequently, public research institutes had been created by the ministry of science and technology; they pioneered the development of a national research capability in scientific fields relevant to electronics, semiconductors and Telecommunication. Together with the growing technological sophistication of private manufacturing sectors, public research institutes provided an important stimulus to the growth of corporate R&D laboratories.³⁴ Recently the WEF-GCI 2009-2010 classified Korea as number 11 globally for its overall innovation competitiveness.

In parallel, it is surprising to discover that the same GCI Report classifies the UAE as an “innovation-driven economy”. This classification is debatable. Indeed, when we examine the characteristics of the three stages of competitiveness defined by the WEF GCI Report, we find that most of the requirements of the first stage - factor driven stage - are fulfilled by the UAE. However for the second stage of competitiveness - indicative of an “efficiency-driven economy” - where competitiveness is increasingly driven by higher education and training, such a pillar was unfortunately shown not to be strong in the UAE context. As for the countries that have reached the innovation-driven stage of development, the report considers that firms in these countries must design and develop cutting-edge products and processes to maintain a competitive edge. This requires an environment that is conducive to innovative activity, supported by both the public and the private sectors. In particular, this means sufficient investments in research and development (R&D), especially by the private sector, the presence of high-quality scientific research institutions and an extensive collaboration in research between universities and industries.

Most of these factors are clearly not satisfied in the context of the UAE economy, where - as previously argued - there is a growing dependency on foreign technology and a need for “integrating and adapting exogenous technologies” and “making incremental improvement to increase productivity”. Furthermore, one can see from next sections that the World Bank’s innovation indicators point to a low innovation level in the UAE, which - paradoxically - confirms the results of the GCI qualitative measures: the UAE’s innovative capacity seems to be constrained by weak “Company spending on R&D”, “Quality of research institutions” and “University Industry Collaboration in R&D”, for which UAE ranked 30th, 53rd and 39th respectively, in 2009.³⁵

³³ “Winning Markets or Winning Nobel Prize: KAIST and the Challenges of Late Industrialization”, op., cit., pp. 157-159

³⁴ “Catching Up and Academic Institutions: A Comparative Study of Past National Experiences”, op., cit., p. 691; and Roberto Mazzoleni and Richard R. Nelson, “Public Research Institutions and Economic Catch-up”, *Research Policy* 36 (2007); pp. 1512-1528, esp., p. 1521

³⁵ “The Global Competitiveness Report 2009-2010”, op., cit., pp. 7, 36, 42, and 317; It is worthy of note that for “Quality of research institutions” and “Company spending on R&D” the UAE ranked 74th and 50th respectively in 2008.



V. Research, Development and Innovation: Academic Production of Knowledge

Innovation is directly related to R&D activities, the support for, and performance in which are mainly measured by the private sector contribution - Business R&D expenditure (BERD) - the Public sector contribution, Government R&D expenditure (GERD) and the Higher Education R&D expenditure (HERD). Investigation of the distribution of R&D in Gulf countries in 1998 indicated that the public sector was responsible for the majority of R&D activities, accounting for 49.4% of all R&D institutions, followed by universities with 43.5% of R&D, then the private sector accounting for a minor 7.0%,³⁶ reflecting a lack of incentives for private sector institutions to invest in R&D in the Gulf. It is very likely that a similar distribution still holds for the UAE. With the establishment of new universities and public research centers, the contribution of the private sector could even have reduced or at best be still at the same level. All this compares poorly to most of the industrialized countries, where more than half of R&D expenditure is financed by the industry.

Patents

Although it is complex to measure R&D output, the numbers of publications and utility patents produced are usually used as indicators to assess the level of research in a country.³⁷ In this regard, the World Bank Innovation System components show modest performance for the UAE.

Precisely, the number of patents granted by United States Patents and Trademarks Office USPTO (measured as an average for the period 2003-2007) was 4.40, corresponding to a score of 5.96 over a maximum of 10. For comparison, Korea scored 9.73 with 5,433 patents (Saudi Arabia scored 7.12 with 18.40 patents). UAE's limited output can be attributed to low spending on research activities and low availability of scientists and engineers in R&D occupations.³⁸

At the academic level though, the United Arab Emirates University (UAEU), a leading national university³⁹, has filed 14 patenting applications between 2007 and 2009, 11 of which from the college of Engineering and 3 from Medicine and Health Sciences faculty. All patents were filed in the name of the UAEU. Japan Cooperation Centre, Petroleum (JCCP) has joined in two of the applications. Other academic utility patents originated from the American University of Sharjah, whose faculty staff is responsible for 9 filed or issued patents in Electrical Engineering since 2000.⁴⁰

³⁶ Samia Satti O. M. Nour "Science and Technology Development Indicators in the Arab Region: A Comparative Study of Gulf and Mediterranean Arab Countries", UNU-INTECH Discussion Papers (August 2005); pp. 17-19

³⁷ "New Indicators for Science, Technology and Innovation in the Knowledge-based Society", ESCWA September (2003); op., cit

³⁸ The World Bank Innovation system pillar is the simple average of the scores on three key variables: Total royalty payments and receipts, Patent applications granted by the US Patent and Trademark Office and Scientific and technical journal articles. World Bank World Bank (KAM): in http://info.worldbank.org/etools/kam2/KAM_page2.asp

³⁹ In 2009 the UAE University was Enrolling 13,740 students (among which 95% are Nationals), employing 842 faculty members with Ph.D. and About 1109 (faculty, instructors, and teaching assistants) see Abdel-Mohsen Onsy Mohamed, Research Affairs, "United Arab Emirates University - the Leading Research and Development Engine of the Arab World", August 26th, 2009 in <http://sra.uaeu.ac.ae>

⁴⁰ United Arab Emirates University, "Research Affairs" (March 2010), p. 39; and American University of Sharjah website: <http://www.aus.edu>

Although such information is not available for all UAE universities - which makes it difficult to accurately estimate their contribution in the scientific invention efforts of the country - one can see from these figures that academic research accounts for an important portion of the national creativity efforts and patent performance in the UAE. Yet, this participation is not fast enough for the country's lag to catch-up with developing and developed countries.

Science and Engineering Publications

The share of the UAE in world publications is also regarded as a useful indicator of the abilities of its researchers, as well as a measure of future potential for their technical development. Globally the relative production of the UAE in S&E publications was around 0.07% in 2008 and 0.06% in 2005, which is extremely low. According to the World Bank, in 2005 the UAE registered 229.26 scientific and technical Journal Articles scoring 5.63 over a maximum of 10. For the same indicator, Korea registered 16,395 scoring 9.38 (for a regional perspective, Saudi Arabia registered 576.30 papers scoring 6.67).⁴¹

Table V: Academic Publications

	Total number of Publications (cumulative)	Co-authored papers (in-country)	Co-authored papers (international)
1995 - 2009	4,925	950	3,975

Source: Zahlan 2010

However, if we focus on the output of research activities undertaken in higher education institutions, and address the quantity and main topics of their scientific publications, we will be able to assess the extent and distribution of their contributions in the national research landscape.

Compiling the research outputs of 16 Science and Engineering universities in the UAE, It was found that these educational organizations published 4,925 papers between 1995 and 2009, thus representing a staggering 93% of the overall national number of science publications. This shows the dominant role of universities in the UAE scientific production. Among these publications, 950 were conducted in collaboration with local research institutions while the rest (3,975) were the product of international cooperation. The UAE University ranked first with a total of 2,981 papers, followed by the American University of Sharjah with 542; the University of Sharjah with 420; the Petroleum Institute with 266 and Zayed University with 256 papers, over the period 1995-2009. The remaining higher education institutions published little; there were 4 universities that published between 50 and 99, and 7 published less than 50 papers.⁴²

Figures from this study by Zahlan show a low national collaboration in the UAE. Indeed, for these leading universities (in terms of number of publications) scientific collaboration within the country represented 2.2% for the Petroleum Institute, 5% for Zayed University,

⁴¹ Scimago Journal and Country Rank in <http://www.scimagojr.com/countrysearch.php?country=AE> and World Bank KAM: http://info.worldbank.org/etools/kam2/KAM_page2.asp

⁴² Antoine B. Zahlan, "Science and Sovereignty, Prospects for the Arab World", Center for Arab Unity Studies (in press). Chapter 6



6% for the American University of Sharjah, 11% for the University of Sharjah, and 26% for UAEU, which may indicate a limited to very limited cooperation among scientists based in the UAE. This may be due to the fact that universities in UAE mainly employ professors from abroad, thus tending to cooperate with scientists from their countries or institutes of origin. However, these figures also show that these universities are able to benefit from international cooperation programs and partnerships, which is vital in a globalized world where scientific and technical communities in different countries are more connected now than they used to be. Furthermore, it is believed that university-mediated transnational conduits of learning will be of particularly great importance during the 21st Century for countries seeking to catch-up, especially regarding public health and medical care, as well as regarding manufacturing technology.⁴³

Over the period 1995-2009, the major part of scientific articles published by UAE universities is in Medicine and Health. On the one hand, the Faculty of Health and Medicine of the UAEU alone published 1,561 papers on health subjects, among which 495 (31.7%) were conducted in collaboration with local institutions. On the other hand, we find that 17 hospitals and the Ministry of Health published a total of 1,517 papers over the same period, for which 49% of the research output was the result of local research⁴⁴. One is tempted to think that the Medical and Health sector in the UAE enjoys a minimum of collaboration between its medical, educational and social institutions. This is particularly important for a field of research where knowledge needs to be suited to local conditions, and where the importance of having the capability to do R&D will be even greater in the future.⁴⁵

Overall, the majority of UAE science publications fall under five main subjects: Medicine (19.4%); Engineering (11.2%); Biochemistry, Genetics and Molecular Biology (7.8%); Computer Science (6.0%); and Agricultural and Biological Sciences (5.9%). (Figure: UAE Publications per Main Subject Area over 1996 - 2008).

One notices that publications in Computer Sciences were low and not increasing significantly over time, whereas the UAE's ICT spending continued to grow from 6.8 billion US\$, in 2005 to 8.2 billion US\$ in 2006 and 9 billion US\$ in 2007. This is all the more so surprising as the country has a clear ambition to enhance its ICT infrastructure, services and related industries. The divorce between HE research and these developments may be due to an excessive reliance on imported ICT goods, services and skills provided by foreign companies, which reflects a lack of national ICT competitiveness.

Energy is also a subject area that curiously did not produce a lot of scientific publications, or research papers from universities. Given the important strategies and projects that are carrying the UAE's most important industry forward and the government's ambitious target to supply 7% of the Emirates' energy needs from renewable energy sources by 2020, one is perplexed by the tiny number of relevant scientific papers (265 in Energy according to Scimago which corresponds to 2.4% of total publications over the period 1996-2008). This mismatch may imply a lack of funding for locally related research on those subject areas.

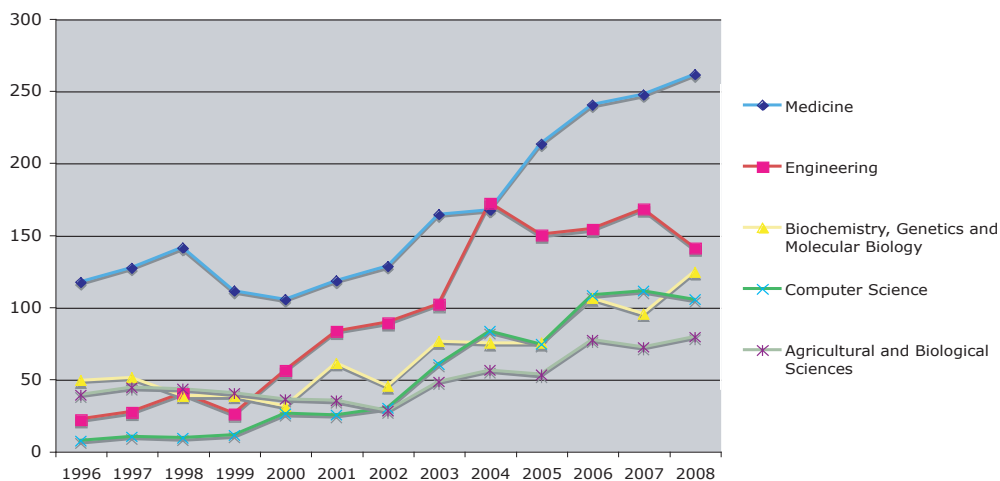
⁴³ "Public Research Institutions and Economic Catch-up", op., cit., p. 1514

⁴⁴ "Science and Sovereignty, Prospects for the Arab World", op., cit., Chapter 6

⁴⁵ "Public Research Institutions and Economic Catch-up", op., cit., p. 1516

In particular, for renewable energy technologies, a strong background in electronics and related R&D are needed to produce photovoltaic equipment. Yet, over the period 1996-2008, the total number of publications in Engineering, which covers all majors from Mechanics, Civil, Electrical and Electronics, were small in number and curiously decreased over the last three years. This shows a weak capacity for new knowledge production in these fields, within the UAE universities.⁴⁶

UAE Publications per Main Subject Area over 1996 - 2008



Source: based on data Retrieved September 16, 2010, from <http://www.scimagojr.com>

VI. Knowledge transfer and problem solving

University-Industry collaboration in R&D

The contribution of HE institutions to the economy can also be detected through cooperation between university colleges and the industrial sector. Industry and academia can form effective partnerships focusing on solving real engineering problems through the utilization of scientific and technological research. Such collaborative R&D gives graduates greater opportunities for learning, helps them develop their competencies and skills - so they become key players in local industry - and consequently leads to building knowledge-based, productive and ultimately competitive firms.

However, universities might find it challenging to attract funding from industry or create a university-industry education program to train students in exchange for what the university has to offer in terms of knowledge, research or facilities.

According to available information and documents, examples of successful R&D cooperation between academia and the industry in the UAE are almost limited to UAEU cooperative projects. For instance, through its Center for Externally Funded Research &

⁴⁶ The National, "Study reflects Abu Dhabi's solar wish list" August 5, 2010 in http://blogs.thenational.ae/the_grid/2010/08/new-yearbook-sheds-light-on-abu-dhabis-solar-wish-list.html



Consultancy (eFORS), UAEU led around 335 collaborative projects from 2001 to 2009 in partnership with national and international industries, for an amount of 56 million UAE Dirhams (15.24 million US\$). This represented 23% of the total internally and externally funded projects in both basic and applied research and a remarkable 62% of the total related funds.⁴⁷ The main research areas of the UAEU collaborative projects were led by the Engineering College on the performance of concrete composition and structures, leading to multiple discoveries and patents. One of these, "Sulfur Modified Concrete" invention forms the basic technology for a joint venture between Al-Qudra Holding - UAE and Nippon Oil Corporation, Japan - towards the establishment of a new sulfur-based concrete plant in Abu Dhabi.⁴⁸

Successful partnerships and mechanisms of knowledge transfer like this one are unfortunately not the norm of all departments or UAE universities. They remain limited in number and type, which minimizes the usefulness of research conducted in UAE universities. But this is not surprising: worldwide, the share of university research that is financed directly by industry remains small. However, industries rely increasingly on university research as their source of innovative technology ideas as the knowledge-intensity of these industries increases.⁴⁹

Nevertheless, the innovative capacity and competitiveness of technology-based industries - in general - cannot be built without investment in R&D and collaboration between industrials and scientists. For this, a strong capacity of fundamental and applied research in higher education and large experience and network of its faculty are paramount to mastering the science and engineering knowledge embodied in imported technology and to successful University-Industry linkages in general. According to Mazzoleni and Nelson, Advanced training in the fields of application-oriented sciences - like chemical and electrical engineering, computer science, biotechnology, and immunology - has become a prerequisite for ability to understand and control those technologies with strong scientific underpinnings. In recent years these fields of science have become increasingly open to those who have the training and connections to get into the relevant networks. Furthermore:

These goals are much harder to attain on the basis of working experience only. In fact, a strong science base significantly reduces the importance of operating apprenticeship abroad, or tutelage by foreign industrial experts. While advanced formal training in a field will not suffice for mastery of specific technologies, it will often provide a substantial basis for learning by doing. Further, having a domestic base of good scientists provides the basis for breaking into the international networks where new technologies are being hatched.⁵⁰

⁴⁷ These figures exclude all scholarships awarded by the University to undergraduate and postgraduate research. UAEU National partnerships included Gulf Extrusion Company, Abu Dhabi Company for Onshore Oil Operations (ADCO), Jebel Ali Free Zone Authority (JAFZA), International Centre for Bio-saline Agriculture (ICBA), Al Ain & Abu Dhabi Municipalities, etc. UAEU Collaboration with the industrial sector continues with a R&D initiative in partnership with Abu Dhabi National Oil Company. This collaboration started with two 3 years-research projects - one on "Enhanced oil recovery" and one on "Corrosion resistance" - involving the college of engineering and for a total amount of 3.4 millions Dirham (925 thousands U.S \$), in Abdel-Mohsen Onsy Mohamed "United Arab Emirates University - the Leading Research and Development Engine of the Arab World", August 26th, 2009 in <http://sra.uaeu.ac.ae>

⁴⁸ United Arab Emirates University, "Research Affairs" (March 2010), p.41

⁴⁹ "Knowledge and Innovation: A discussion Paper", op., cit., p.16

⁵⁰ "Public Research Institutions and Economic Catch-up", op., cit., p.1515

This highlights the growing importance of developing indigenous technological capabilities through educational and research activities conducted in domestic universities and public laboratories.

In particular:

Achieving competence in many areas of manufacturing requires staying up with a moving target. Further, as the frontier is approached, the lines between sophisticated imitation and creative design of new products and processes become blurry. A strong R&D capability becomes essential. To a considerable extent the R&D needs to go on in firms. However, research in universities and public laboratories can play a strong supporting role, and one that is likely to take on different connotations at different stages of the process of catching up.⁵¹

However, according to the Abu Dhabi Education Council (ADEC), both public and private universities need to address capacity and quality challenges. In addition to poorly prepared school-leavers and limited and “unfocused” courses, these include difficulty in attracting and retaining quality teaching staff, insufficient funding, and a dearth of research.⁵² Indeed, the impermanence of jobs in the UAE limits the cumulative knowledge and connection benefits that the research community and technology-based industries may derive from the importation of scientists, as knowledge transfer between university and the different sectors of the economy is largely based on the engagement of researchers and their experience. Hence such impermanence and discontinuity may curb national cooperation and slow down the development of the knowledge-based economy that the UAE seeks to build.

Conclusion

Science and engineering will play a key role in the future of the UAE economy. The present analysis indicates that in order to improve the performance of the higher education system in the formation and accumulation of indigenous technological capabilities and skills, the UAE needs to invest heavily in both capacity and research capabilities of their academic institutions.

However, reinforcement and financial support of these institutions should be harmonized with policies that provide incentives to enterprises for upgrading their R&D activities, as these investments and support will be more effective if they are linked to well-defined long term developmental plans that cover industrial, S&T research and human development policies and programs.

To build a knowledge-based economy and ensure the competitiveness of its economy through innovation, the UAE will need to create more and better employment opportunities

⁵¹ Ibid., pp. 1516-1517

⁵² The national, “Billions invested into university research” by Melanie Swan and Kathryn Lewis June 10th 2010; in <http://www.thenational.ae/apps/pbcs.dll/article?AID=/20100610/NATIONAL/100619985/1010>



for highly skilled personnel as part of its development priorities. It will also need to adapt R&D to local concerns and priorities and in the same time be responsive to the evolving technological capabilities of its local industries.

Particularly, authorities should tackle the issues related to the interfacing of the educational programs offered by domestic academic institutions and the evolving needs of the local enterprises. Since academic institutions can support and contribute significantly to a country's economic development, universities will be expected to be more innovative. For this, the differentiation of academic institutions in terms of their training and research goals is necessary in order to ensure an effective relation between the academic research and the productive sector of the economy. Not only should they be reinforced in order to provide society with trained engineers and applied scientists, it should also be ensured that supply matches demand through the supply of technical expertise, the conduct of fundamental research, and adaptive forms of collaboration with local industries that are learning to do their R&D.