Role of statisticians in building the UAE knowledge economy
By Hijazi, Saeed, Alfaki

Role of statisticians in building the UAE knowledge economy

Rafiq Hijazi[*a], Raed Saeed[b], and Ibrahim Alfaki[c]

[a]*University and department, Al Ain University of Science and Technology, United Arab Emirates, Department of Business Administration*
[b]*Canadian University Dubai*
[c]*UAE University*

This paper provides an overview of the use of statistics in the workplace in the United Arab Emirates (UAE), and the role statistics and statisticians play in the country's endeavors to transform to a KE. The paper further elucidates the gap between statistics education and the labor market needs. Information are garnered from a sample of 104 statisticians and practitioners with related backgrounds on several issues covering the level of statistical practice in the country, training and professional development and the role statisticians play in supporting research and decision making. Evidence reveals a growing recognition of the role of statistics in the country. Several limitations, however, were noted including increased shortages in supply of statisticians and a lack of indepth professional training in traditional and emerging statistics topics together with a lack of quality research output.

keywords: Knowledge Economy, UAE, Statistics in Workplace, Statistics Education.

1 Introduction

A few years ago, the United Arab Emirates (UAE) cabinet declared its 2021 vision of making the UAE among the best countries in the world through building a diversified knowledge economy (UAE Cabinet, 2010). In consonance with this vision, the move towards knowledge economy has been accentuated in Abu Dhabi's Economic Vision 2030

---

*Corresponding author: rafiq.hijazi@aau.ac.ae

(Abu Dhabi Government, 2007) and Dubai's Strategic Plan 2021 (Dubai Government, 2014). Based on the Knowledge Economy Index (KEI), developed by the World Bank, the UAE has made a noticeable progress towards the creation of a competitive knowledge economy and has been ranked 42nd globally and first in the Arab World with a score of 6.94 out of 10 (World Bank, 2012). The individual scores on the KEI components were Economic Incentive and Institutional Regime (6.50), Education (5.80), Innovation (6.60) and Information & Communications Technology (8.88). This reflects the remarkable progress achieved in building the IT infrastructure; however, it highlights the concerns about weaknesses in education and innovation sectors. To address such weaknesses, Parcero and Ryan (2016) recommended developing a research culture and improving the incentives to attract high quality researchers and talented workers. Recognizing this hurdle, the UAE 2021 vision aims to place innovation, research, science and technology at the center of agenda to build knowledge economy. Definitely, investment in education, innovation, information and communication technologies and creation of conducive economic institutional environment will all lead to an increase in the use of knowledge in the economy, and will subsequently result in sustained economic growth (Chen and Dahlman, 2005).

Undoubtedly, statistics has contributed greatly to building knowledge economies not only by supporting economic and political systems but also through the creation of a knowledge society (Giovannini et al., 2009; Carss, 2002) and influencing the prosperity of nations as well (Stigler, 2005). The effective use of statistical information and methods plays a vital role in improving business processes and facilitating innovation (Box and Woodall, 2012; Hahn and Doganaksoy, 2008; Pantula, 2011; Jensen et al., 2012; Anderson-Cook, 2015; Snee, 2005). Hockman and Jensen (2016) emphasized that statisticians, with certain additional skills, can play a critical role in facilitating, and even leading, innovation efforts. Moreover, statistical analysis has become a fundamental component of modern research in all disciplines (Sahai and Lovric, 2011). More importantly, the availability of relevant official statistics is very crucial for monitoring the progress towards the aspired knowledge economy and for providing leaders, decision makers, and international organizations with key indicators and updated information about economic and social development (Khan, 2013). In well-established knowledge economies, statisticians are employed in a diversity of fields across government agencies, businesses and industry (Jeske and Myhre, 2011; Hahn and Doganaksoy, 2011). Statisticians are generally engaged in statistical consultations which usually involve collection, summary, analysis of data, and interpretation of results; hence, they contribute to the promotion of solid evidence-based decisions in the workplace. Nevertheless, many statisticians have gone beyond consultation and become leaders in various fields (Wasserstein, 2016). In light of this, the role of statistics and statisticians is expected to grow rapidly with the growth of big data and complex problems in various disciplines (Efron, 2011; Kettenring et al., 2015).

This paper aims to provide an overview of the use of statistics in the UAE workplaces and to investigate the role of statistics and statisticians in the UAE's endeavor to build a knowledge economy. It additionally examines bridging the gap between statistics education and the labor market needs.

The organization of the remaining sections is as follows. Section 2 provides an overview of statistics and statisticians in the UAE, followed by a brief literature review on the use of statistics in the workplace in Section 3. Section 4 outlines the research methodology including survey design and data collection while the survey results are presented and discussed in Section 5. Finally, conclusions and recommendations are presented in Section 6.

2 Statistics and Statisticians in the UAE

Over the last decade, the UAE leadership, driven by its commitment to building a knowledge economy and its recognition of the importance of statistics, has paid great attention to promoting the use of statistics as a fundamental force in economic and social development, decision and policy making, and good governance. This recognition has been translated into the establishment of The National Bureau of Statistics (NBS) in 2009 to be the sole source of official statistics in the country. In 2015, The Federal Competitiveness and Statistics Authority (FCSA) has been established to replace the NBS with an updated and innovative mission to strengthen and enhance the UAE's national data and competitiveness capacities and to improve the UAE ranking in the global competitiveness indices and reports (Federal Authority for Competitiveness and Statistics, 2015). Meanwhile, emirate-based statistics centers were also established including Dubai Statistics Center (DSC) in 2006, Statistics Center- Abu Dhabi (SCAD) in 2008, Fujairah Statistics Center in 2009, Sharjah Department of Statistics and Community Development in 2012 and recently Ras Al Khaimah Center for Statistics and Studies in 2016. In the emirates of Ajman and Umm Al-Quwain, the local departments of economic development are serving as statistics centers in addition to other economic and social mandates. Moreover, nearly every federal and local government agency (ministry, authority, municipality, police, armed forces etc.) has an internal statistics unit/office to meet its statistical needs and provide main statistics centers with timely and accurate information. Interestingly, most statisticians in the UAE hold positions in the public sector and are rarely hired by the private businesses and industries where the statistical work is performed mainly by nonstatisticians.

Most emirates have initiated excellence programs with the aim of promoting excellence in government performance. The programs have significantly reinforced and enhanced the use of statistics in monitoring organizational performance and achieving customers' satisfaction. Notable examples of these programs include Abu Dhabi Award for Excellence in Government Performance and Dubai Government Excellence program. Additionally, the growing culture of accreditation and quality assurance in the UAE has strengthened the role of statistics in healthcare, education, industry and other fields. The increased attention to the importance of statistics in the UAE was clearly reflected in hosting several international conferences related to statistics including Abu Dhabi Statistics Conference 2013 on improving quality of administrative data, the 15th Conference of the International Association for Official Statistics (IAOS) in December 2016, and the United Nations World Data Forum in October 2018.

Despite all these efforts, a significant proportion of the UAE key development indicators released by the World Bank and other international organizations are missing, mainly due to failure of official sources and data agencies in the country to release the data needed to prepare these indicators. Moreover, statistical studies produced by the various statistics centers and other official agencies are below expectations in terms of quantity and quality. A close review of the analytical reports on the Household Expenditure and Income Survey in the UAE (Dubai Statistics Center, 2018) reveals lack of quantity and quality, compared, for instance, with the US Consumer Expenditure Survey reports produced by the Bureau of Labor Statistics (Bureau of Labor Statistics, 2018). According to Ryan and Daly (2018), this is mainly attributed to the lack of institutional research and norms within UAE organizations, in addition to an apparent weakness in the research methods. Such deficiencies and data shortages will definitely hinder the process of monitoring the progress towards the aspired knowledge economy and is likely to impede promotion of transparency and accountability.

However, despite the impressive growth of the UAE's higher education sector in the last decade, the country is still suffering from insufficient supply of statisticians. The United Arab Emirates University (UAEU) remains the only supplier of statisticians to the labor market in the country. In addition, the government move to only employ UAE citizens in the federal agencies and the public sector, in accordance with the country's declared "emiratization and nationalization" polices, imposes restrictions on hiring expatriate statisticians (Hijazi, 2014). Lack of quality data and insufficient supply of statisticians are not the only source of concern; rather, aligning statistics curricula and learning outcomes in higher education institutions with market needs is a task of paramount significance.

3 Literature Review

Over the last few decades, efforts have been made to identify the statistical knowledge and skills needed by statisticians in various workplaces. Issues related to workplace training and mismatch between university statistics education and workplace needs have widely been discussed. Most of these efforts are translated into the research output of conferences organized by the International Association for Statistical Education (IASE), in particular the International Conference on Teaching Statistics (ICOTS) and the IASE Satellite Conference. Harraway and Barker (2003, 2005), for instance, investigated the use of statistics in the workplaces in New Zealand. In the UK, the MEANS project (Holmes, 1997) aimed at reducing the gap between the statistical training received in higher education and graduates' subsequent employment. Other similar studies have been conducted to explore the use of statistics in specific workplaces with the aim of identifying the necessary qualifications needed by graduates of statistics. For example, Eldridge et al. (1982), Hole et al. (1997) and Denis et al. (2002) have focused on investigating the preparation of statisticians for careers in government and statistics agencies, while Gullion and Berman (2006) researched the role of statistical consultants. Much of recent research has concentrated on exploring workplace learning and

work experiences together with professional development, including statisticians and non-statisticians training needs (Westbrooke and Rohan, 2014; Hamilton, 2010).

As discussed earlier, statisticians are generally employed by various public and private organizations to actively and effectively use statistics for decision-making purposes. In the government sector, statisticians play a critical role in the preparation and reporting of performance indicators together with designing and conducting surveys, and reporting the results (Eldridge et al., 1982; Hahn and Doganaksoy, 2011). In the business and industry sectors, statisticians are mainly engaged in activities related to quality control, product development and improvement, and business process improvement (Coleman et al., 2008; Hahn and Doganaksoy, 2008, 2011).

Although there is a general consensus on the importance of statistics in the Arab World, particularly in the Gulf Cooperation Council (GCC) countries, very little work has been done to investigate the utilization of statistics in this region. Three decades ago, Loynes (1987) investigated the training of statisticians around the world. His study included two Arab states, namely Morocco and Jordan. Additionally, Osman and Ismail (2009) discussed the statistical knowledge and skills that statisticians working in policy research centers in Egypt need. Recently, Hijazi (2014) explored the supply and demand cycle for statisticians in the UAE and reflected on the challenges faced in this area.

4 Research Design

4.1 Questionnaire

To address the research objectives, a survey of statisticians and statistics practitioners working in the UAE was conducted. The survey process started by constructing a comprehensive questionnaire consisting of five parts. The first part solicited demographic information and details about the workplace. The second part was designed to gather information about the use of statistics in the workplace including methods, software and activities (Harraway and Barker, 2005) while the third part focuses on the role of statistics and statisticians in the workplace. In the fourth part, participants were asked to rate the quality of statistics education they have received and its relevance to their job requirements. Finally, the last part was intended to explore professional development and statistical training needs and opportunities that might be available for statisticians in the workplace (Romeu, 2006; Harraway and Barker, 2005). The questionnaire was deployed online with both English and Arabic versions to eliminate language bias.

4.2 Data Collection

The exact number of statisticians and statistics practitioners working in the UAE is unknown; hence, no reliable sampling frame for this study was available. To establish a reliable sampling frame for this study, a list of major workplaces in all seven UAE emirates employing statisticians was prepared. The list constitutes all statistics centers in the country, federal and local government agencies, police and armed forces departments, research centers, universities and major hospitals. Contact information for all

workplaces in the list were gathered from online sources and websites, and where online sources were not available information were solicited by direct phone contact.

The data collection process started by sending an official email along with a copy of the questionnaire to the targeted workplaces to get their approval to participate in the study. After getting the approval from these workplaces, an invitation to complete an online questionnaire was emailed to the contact person to share it with statisticians and statistics practitioners in his/her workplace. At the same time, the UAEU statistics alumni were invited by phone to participate in the survey based on a list of around 110 provided by the Statistics Department at UAEU. However, most of the listed phone numbers were unfortunately either wrong or not in service and only around 20% of the names on the list responded to the survey. Two more email reminders were sent within a month in an effort to improve the response rate. Overall, 104 questionnaires were fully completed from around 40 different workplaces across the UAE. A display of the responding entities which includes all statistics centers and other workplaces in the UAE is shown in Table 1 below.

Table 1: Workplace and Respondents' Affiliation

	Number	Respondents	% of Respondents
Statistics Centers	5	26	25
Government (Ministries, authorities, etc.)	26	64	62
Business/Industry	8	14	13
Total	39	104	

4.3 Data Analysis

Due to the descriptive nature of the study and the moderate sample size used, the study relied mainly on descriptive statistics techniques. It further investigated the differences in the statistical practices utilized by the respondents across the various workplaces and educational levels using Chi-square techniques and Mann-Whitney test.

5 Results and Discussion

Table 2 presents the key characteristics of the 104 respondents in this study. Around two-thirds of the respondents were males (64%) and 61% were UAE nationals. Over 90% of the respondents work in the public sector at the federal or local emirate levels. More than half of the sample respondents (55%) were from Abu Dhabi. In terms of educational level, slightly more than half of the respondents hold undergraduate degrees in statistics mostly from the UAEU while 16% hold postgraduate degrees in statistics. Nearly one-third of the respondents have education in related fields, mainly in economics. Finally, the age distribution shows that 41% of respondents were below 30 years of age indicating a significant participation of new graduates in the labor market. This, in fact, is a supporting evidence for the growing demand for statisticians in the UAE labor market.

Table 2: Characteristics of the respondents

	Frequency	Percentage		Frequency	Percentage
Gender			*Nationality*		
Male	67	64%	UAE	63	61%
Female	37	36%	Expatriate	41	39%
Statistics Qualification			*Workplace Location*		
UG degree in Statistics	54	52%	Abu Dhabi	57	55%
PG degree in Statistics	17	16%	Al Ain	12	11%
UG degree in related field	24	23%	Dubai	10	10%
PG degree in related field	9	9%	Northern Emirates	25	24%
Age			*Type of Employers*		
20-29	41	41%	Federal Government	14	13%
30-39	31	31%	Local Government	81	78%
40 and above	29	29%	Private Sector	9	9%

5.1 Use of Statistics

To explore the use of statistics in the workplace, the respondents were asked to indicate which statistical techniques and packages are commonly used in their daily activities. Table 3 shows that the respondents generally rely on employing sample surveys in collecting the required data and on using descriptive statistics techniques to analyze these data. As data producers, statisticians affiliated with statistics centers are heavily involved in collating official and administrative data and official statistics, mainly used for preparing social and economic indicators. They further utilize time series analysis and forecasting techniques to identify possible patterns and trends of created indicators. Surprisingly, the results, in Table 3, indicate that only less than one-third of the respondents use statistical inference, modelling and advanced techniques. The findings appear to be consistent with the expectations noted by Hahn and Doganaksoy (2011). However, lack of regular comprehensive national surveys and longitudinal studies that require complex sampling designs and demand new statistical methodology might explain the low use of advanced statistical techniques in these agencies. Even when comprehensive surveys are conducted, it seems that the intended objectives are either exploratory or not fully addressed in the subsequent analysis of the collected data. For instance, the Household Expenditures and Income Survey, conducted by DSC, has 12 objectives which are mainly exploratory or descriptive. Moreover, after reviewing the research explored in this survey, including reports produced by DSC, it seems that only very few studies have addressed higher level objectives using deep analysis and inferential techniques (Dubai Statistics Center, 2018; Azzam and Rettab, 2013). The main activity of almost all statistics agencies operating in the country is the routine reporting of official statistics over time and the crude publication, mainly in tabular format, of conducted national surveys, including household expenditure, income and labor force surveys. Definitely, thorough and high level statistical analysis and inferential research of data gathered from such surveys within the agencies or in collaboration with universities and other research centers would provide a solid basis for sound decisions. Similar pattern of activities and reliance on the use of descriptive statistics and survey design and analysis were observed with statisticians from both the UAE government and the business and industry sec-

tors. Based on Chi-square test of homogeneity, there are significant differences only in the use of official statistics among the different workplaces (*p-value*=0.003). Overall, these results confirm, to some extent, the findings reported by Harraway and Barker (2003, 2005) in their studies of graduates in New Zealand.

Consistent with the reported use of statistical techniques, the vast majority of respondents indicated heavy reliance on the use of Excel in data analysis as shown in Table 3. This is very similar to the results reported by Harraway and Barker (2005) in their study of New Zealand workplaces. Excel is widely accessible in all workplaces in the UAE while SPSS is available only in few government agencies across UAE. However, SAS is expensive and is only available in a couple of statistics centers which explains the significant differences in its use across the different types of workplace (*p-value*=0.008).

Table 3: Statistical techniques and software use in workplace

	Workplace		
	Statistics Center $n = 26$	Government $n = 64$	Business $n = 14$
Statistical Techniques			
Descriptive statistics	84%	80%	69%
Basic tests (t-tests, Chi-Square, ANOVA)	32%	27%	7%
Regression analysis	32%	29%	29%
Time series analysis	52%	38%	43%
Survey methodology	64%	57%	57%
Multivariate analysis	24%	24%	29%
Official statistics	72%	38%	21% *
Statistical Software			
Excel	100%	91%	100%
SPSS	48%	33%	21%
SAS	24%	5%	0% *

* Denotes group differences significant at 0.05 level based on Chi-Square Test of Homogeneity.

Table 4 provides a summary of the statistical activities carried out in the surveyed workplaces classified by the type of workplace and the educational level of respondents. Data analysis and report writing represent the dominant activities in all workplaces. The majority of respondents from government and statistics centers reported designing studies and surveys as key activities they perform, compared to around one-third of their counterparts working in the business sector. It is noted that respondents with postgraduate education have significant higher level of participation in these activities particularly in data analysis, report writing, and designing studies and surveys. Overall, the respondents showed high level of participation in the main activities expected in modern workplaces especially in government and statistics centers.

Table 4: Statistical activities in the workplace

	Workplace			Education level	
	Statistics Center	Government	Business	Undergraduate	Graduate
	$n = 26$	$n = 64$	$n = 14$	$n = 78$	$n = 26$
Data analysis	84%	78%	93%	77%	96% *
Designing Studies	68%	57%	36%	51%	73% *
Designing Surveys	68%	59%	36%	52%	77% *
Report writing	88%	83%	86%	79%	100% *
Review/interpret analytic results	68%	63%	57%	56%	85% *
Training statistical personnel	76%	27%	14% *	34%	46%

* Denotes group differences significant at 0.05 level based on Chi-Square Test of Homogeneity.

5.2 Workplace Learning and Professional Development

The statistics profession is rapidly changing in terms of application areas, technology and data revolution; therefore, statisticians should keep abreast with the latest developments in the filed (Nolan and Temple Lang, 2010; Hahn and Doganaksoy, 2011). Undoubtedly, they should have the passion of a lifelong learning through self-directed learning and professional development. The upper part of Table 5 shows a summary of the various learning strategies adopted by the respondents in acquiring statistical knowledge after graduation. Based on Chi-square test of homogeneity, there are no significant differences in these learning strategies among the various workplaces. More than half of the respondents from statistics centers and around one-third of those from government and business use hard-copy materials. This observed difference might be attributed to the expected availability of in-house libraries in statistics centers. Similar patterns, with varying levels, have been reported by respondents on using web-based materials, attending conferences and taking training courses. Moreover, mentoring is another strategy for acquiring statistical knowledge as reported by over one-third of the respondents. This strategy is a very important catalyst for career development and effective integration of junior statisticians within the workplace environment (Anderson-Cook et al., 2017). Evidence presented in Table 5 shows that following online courses in statistics is not a popular choice among the surveyed respondents.

The lower part of Table 5 depicts respondents' feedback with regard to statistical training as a vital component of professional development. Among the respondents, nearly three-quarters from statistics centers, 60% from government and less than half of those working in business have received statistical training in the previous year. Most of the statistics centers, e.g. SCAD and FCSA, offer in-house statistical training for their staff and other government entities. Although attending training sessions is obligatory in the government, such training sessions are not in high demand. Typically, statistical training offered for staff employed by government and business is at introductory level and mainly replicates the content covered in a basic statistics course offered at the college. This, to a considerable extent, explains and justifies the perceived inadequacy of the offered training opportunities. Within this context, as presented in Table 5, respondents expressed a high demand for further training in various subject areas, in particular in data management and statistical packages, survey design and analysis, and official statistics. On the other hand, the respondents indicated less interest in advanced

topics such as regression and multivariate analysis, possibly due to lack of extensive use of these techniques in daily activities as observed earlier. Moreover, some respondents requested additional training topics such as simulation, programming, data mining, and big data analysis. Generally, any workplace statistical training should provide adequate up-to-date and focused sessions that respond to the trainees' needs (Westbrooke and Rohan, 2014). It is worth noting that the 2018 training calendar prepared by the Statistical Training Institute in SCAD provides integrated training modules covering almost all requested topics and many more (Statistical Training Institute, 2018). However, a thorough revision of professional statistical training is needed to cope with global information growth and new tools of data analysis.

Table 5: Professional development and statistical training at the workplace

	Workplace		
	Statistics Center	Government	Business
	$n = 26$	$n = 64$	$n = 14$
Acquiring Statistical Knowledge			
Reading hard copy materials (books, journals, etc.)	52%	32%	29%
Reading Web materials	64%	52%	50%
Following on-line courses	4%	13%	7%
Attending conferences	48%	39%	29%
Taking training courses	60%	49%	29%
Mentoring from experienced work colleagues	36%	41%	29%
Hours of training received last year			
None	24%	41%	54%
1- 19	32%	39%	15%
20+	44%	20%	31%
Adequacy of training opportunities	39%	24%	54%
Statistics training needs			
Multivariate analysis	44%	52%	38%
Advanced regression models	36%	49%	23%
Data Management and packages	56%	77%	85%
Survey design and analysis	68%	69%	54%
Demography	44%	44%	46%
Official statistics	72%	62%	54%

5.3 Role of Statistics and Statisticians in Workplace

Recent years have witnessed a remarkable increase in the role of statistics and statisticians in the UAE as mentioned earlier. To further explore how this phenomena is translated in the workplace, the respondents were asked to indicate their opinion on the role and importance of statistics, see Table 6 for results. The majority of respondents confirmed the increased importance of statistics and its utilization in activities in almost

all sectors in recent years. Moreover, involvement of statisticians in the UAE in planning and designing statistical activities has increased as well, mainly for those employed in statistics centers and particularly among statisticians with postgraduate education. These changes were accompanied by tangible and efficient statistical work as perceived by the majority of respondents across the various workplace and significantly among respondents with graduate education (*p-value*=0.031). This, no doubt, attests to the growing efforts to promote the role of statistics and statisticians in decision-making in the UAE government, industry and business sectors.

Table 6: Role of statistics in workplace

	Workplace			Education level	
	Statistics Center	Government	Business	Undergraduate	Graduate
	$n = 26$	$n = 64$	$n = 14$	$n = 78$	$n = 26$
Importance of Statistics	76%	67%	100%	68%	86%
Involvement in Planning	80%	61%	42%	58%	77%
Efficiency of Statistical Processes	95%	76%	73%	75%	96% *

* Denotes group differences significant at 0.05 level based on Chi-Square Test of Homogeneity.

5.4 University Preparation

An important goal of programs that educate statistics is building and improving a country's statistical capabilities (Robison, 2010). Evidently, as discussed earlier in this paper, the UAE is actively working on improving its statistical system. Usually, different factors contribute to improvement of a statistical system, including investment in preparing a qualified statistics cadre that possesses the right mix of statistical theory education, practice and other related skills. This, indeed, would require the thorough recruitment of graduates and professionals who have at least college degrees in statistics and/or other related fields from accredited colleges and universities to work in statistics and data management and analysis agencies. Table 7 below shows that the UAEU is the main source of qualified professionals (more than half the sample) with bachelor degree in statistics or related fields employed in the government, business or statistics agencies throughout the country. The respondents indicated that they have appropriately covered almost all main traditional topics in statistics. Those with a bachelor degree in statistics have reported above average (more than 3 points) satisfactory score with regard to their understanding and use of statistical techniques such as regression analysis, time series analysis, survey design and multivariate data analysis in daily workplace activities.

Official statistics as a topic has received more attention from respondents who have a bachelor degree in fields different from but related to statistics. This might be attributed to the fact that official statistics is usually heavily used in preparation of social, economic and other human development indicators which are typically discussed by professionals with background or specialization other than statistics. Based on Mann-Whitney test, UAEU students were less satisfied with the education received on official statistics particularly those with degrees related to statistics compared with their counterparts graduated from other universities (*p-value*=0.037). As noticed earlier, there is a high level of usage of official statistics particularly among the respondents employed

by statistics centers (Table 3) in addition to the high demand for training in this topic (Table 5). Consequently, to align the statistics education with the labor market needs, it is recommended to incorporate official statistics in the requirements of the statistics program offered at UAEU.

It is interesting that statistical quality control as a topic received a low score (below average) in Table 7. In fact, quality control techniques describe statistical methods that are employed mainly by business and industry to monitor and maintain quality of products and services. So since most of our sample is from the government and official agencies, this lack of interest in statistical quality control techniques is expected. Moreover, this course is a typical elective course in most undergraduate statistics programs, including the statistics program offered at UAEU (UAE University, 2018). Nevertheless, some of the quality control techniques are covered in other courses in business schools such as quality and operations management. Overall, it is clear from Table 7 that the respondents were happy (above average score for all, except for those with a degree in other fields, 2.63) with the statistics education they received. Accordingly, they indicated an overall preparedness to handle workplace statistical activities (above average score of 3.56 for UAEU and 3.57 for Other), except those with a degree in fields related to statistics (below average score of 2.63 for UAEU and 2.85 for Other).

Table 7: Statistical preparedness for the workplace

	Bachelor in Statistics				Bachelor in related field			
	UAEU		Other		UAEU		Other	
	$n = 45$		$n = 7$		$n = 8$		$n = 13$	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Preparation in statistical topics								
Regression Analysis	3.56	1.16	3.86	0.90	2.63	1.06	3.00	1.08
Time series Analysis	3.78	1.15	3.43	0.98	2.63	1.06	2.92	1.19
Survey Design and Analysis	3.69	1.10	4.00	1.15	2.50	1.07	3.08	0.86
Multivariate Analysis	3.44	1.12	2.86	1.46	2.25	1.16	2.92	1.26
Statistical Quality Control	2.93	1.50	2.43	1.27	2.13	1.25	2.69	1.18
Official Statistics	2.89	1.39	3.43	1.27	2.38	0.92	3.38	1.12 *
Statistics education	3.89	0.88	4.00	0.82	2.63	0.74	3.08	0.86
Preparedness for the workplace	3.56	1.01	3.57	0.79	2.63	0.74	2.85	0.69

* Denotes group differences significant at 0.05 level based on Mann-Whitney Test.

6 Concluding Remarks and Recommendations

Adopting a knowledge economy framework entails more reliance on intellectual capabilities and educational attainments. Statistics work and education, in particular, are closely linked to building human capital in terms of ability and experiences needed by statistical systems to assess and support progress in realization of national strategies and

visions, in addition to providing evidence-based information that help decision-making in the government, business and industry. This study has focussed on investigating the state and role of statistics and statisticians in building a knowledge economy in the UAE.

The UAE has made a notable progress in acknowledging the importance of statistics as a tool that offers essential insight into and solutions to many data-dependent problems. To further elucidate the role of statistics and statisticians in the UAE, the study surveyed the opinion and feedback of a sample of 104 statisticians and other practitioners representing the government, statistics agencies and business and industry sectors. Evidence shows that the UAE is suffering from an insufficient or decreasing supply of graduate statisticians from local higher education institutions (UAE University, 2016, p. 8; UAE University, 2017, p. 44). The UAEU has been basically the sole supplier of statisticians in the country, no other college or university offers statistics education. This is detrimental and is in sheer contrast with international trends. International evidence shows that both supply of and demand for statisticians are rapidly increasing, with demand hugely exceeding supply (Pierson, 2014). Based on this, the UAE should make a significant move, in coordination with higher education institutions, to tackle the growing shortage in national statisticians and statistically trained workers. This could be achieved, for example, by encouraging more graduates to go into statistics education as well as recruiting students from other fields into minors in statistics. Meanwhile, the statistics program offered at UAEU should be aligned with the needs of the UAE labor market by placing more emphasis on traditional areas such as official statistics, sampling surveys and quality control, and updating the curriculum to include emerging areas such as big data, data analytics, and data science.

Research and Development (R&D) is a critical pillar in the industrial and business sectors in countries adopting knowledge economy framework (World Bank, 2012). It aims at improving existing products and processes. It fundamentally depends on applying statistical methods and understanding the development, improvement and optimization of new products and processes. The UAE business and industry sectors, however, seem to lack full appreciation of the role that statistics, statisticians and R&D might play in improvement of the production processes; only 13% of the sample respondents in this study were affiliated with the business and industry sectors. It is noticeable that the main role played by UAE statisticians basically conforms to the traditional use of statistical techniques in collecting data and conducting simple sampling surveys, ending up with simple descriptive reports. The study revealed that deep analyses of data and R&D activities that might have significant impact on decision making together with improvement of products and processes are limited in number and quality. This is a clear message to the government, business and higher education institutions to utilize available statistical expertise to work together towards upskilling research capabilities of statisticians and other workers in the field of information and data science. This could be achieved through close and active collaboration between statistics agencies, the government and academic statisticians. Moreover, making census and survey data available to researchers, in a controlled and secure manner, would help in producing high quality analysis reports and supporting the research and innovation on the road to building the aspired knowledge economy.

The infrastructure in most statistical agencies in the UAE, ranging from computing power, communication and technological readiness seem to be adequate. Although the majority of the sample respondents have expressed satisfaction with the role statisticians play in the country, the study; however, has revealed inadequate levels of statistics training and professional developments among these cadres in several areas, including data management, complex survey design methodologies, utilization of professional statistical packages and advanced modeling and computing skills. Availability of such skills and experiences is critical to accentuate the role of R&D in the UAE knowledge economy transformation process. More efforts, therefore, need to be invested in bringing the training levels to higher standards to include emerging topics in statistics.

Finally, the other GCC countries share the UAE similar culture, knowledge economy ambition, and the state of statistics and statisticians as well. Hence, early recommendations in this study that aimed to enhance the UAE statistical capabilities and promote the use of statistics in all aspects of decision-making and policy formulation towards achieving their vision of building competitive knowledge economies are also applicable to other GCC countries.

References

Abu Dhabi Government (2007). Abu Dhabi Economic Vision 2030. `https://www.econcil.ae/PublicationsEn/economic-vision-2030-full-versionEn.pdf`. [Online; accessed April 26, 2019].

Anderson-Cook, C. M. (2015). Opportunities to empower statisticians in emerging areas. *Applied Stochastic Models in Business and Industry*, 31(1):3–11.

Anderson-Cook, C. M., Hamada, M. S., Moore, L. M., and Wendelberger, J. R. (2017). Statistical mentoring at early training and career stages. *The American Statistician*, 71(1):6–14.

Azzam, A. and Rettab, B. (2013). Food price cap policy and household welfare in the UAE. *International Journal of Economic Policy in Emerging Economies*, 6(1):64–77.

Box, G. E. and Woodall, W. H. (2012). Innovation, quality engineering, and statistics. *Quality Engineering*, 24(1):20–29.

Bureau of Labor Statistics (2018). Consumer expenditure survey. `https://www.bls.gov/cex/csxreport.htm`. [Online; accessed April 26, 2019].

Carss, G. (2002). The role of the statistician in the knowledge-based economy. In *International Association for Official Statistics conference on "Official Statistics and the New Economy", August*, pages 27–29.

Chen, D. and Dahlman, C. (2005). The knowledge economy, the KAM methodology and World Bank operations. *World Bank Institute Working Paper*, (37256). `https://ssrn.com/abstract=841625`. [Online; accessed April 26, 2019].

Coleman, S., Greenfield, T., Stewardson, D., and Montgomery, D. C. (2008). *Statistical practice in business and industry*. Chichester, UK: John Wiley & Sons.

Denis, J., Dolson, D., Dufour, J., and Whitridge, P. (2002). Preparing statisticians for a career at Statistics Canada. Technical report, Citeseer.

Dubai Government (2014). Dubai Strategic Plan 2021. `http://www.dubaiplan2021.ae/dubai-plan-2021/`. [Online; accessed April 26, 2019].

Dubai Statistics Center (2018). Household expenditure and income survey. `https://www.dsc.gov.ae/en-us/Programs-Statistical-Surveys/Pages/Statistical-Project-details.aspx?ProjectId=23`. [Online; accessed April 26, 2019].

Efron, B. (2011). The future of statistics. In *International Encyclopedia of Statistical Science*, pages vii–x. Springer Berlin Heidelberg.

Eldridge, M. D., Wallman, K. K., Wulfsberg, R. M., Bailar, B. A., Bishop, Y. M., Kibler, W. E., Orleans, B. S., Rice, D. P., Schaible, W., Selig, S. M., et al. (1982). Preparing statisticians for careers in the federal government: Report of the asa section on statistical education committee on training of statisticians for government. *The American Statistician*, 36(2):69–81.

Federal Authority for Competitiveness and Statistics (2015). Establishment law of Federal Authority for Competitiveness and Statistics. `http://fcsa.gov.ae/en-us/Pages/About-Us/Establishment-Law.aspx`. [Online; accessed April 26, 2019].

Giovannini, E., Martins, J. O., and Gamba, M. (2009). Statistics, knowledge and governance. *Statistika*, (6):471–490.

Gullion, C. M. and Berman, N. (2006). What statistical consultants do: Report of a survey. *The American Statistician*, 60(2):130–138.

Hahn, G. J. and Doganaksoy, N. (2008). *The role of statistics in business and industry*. New Jersey, Hoboken: John Wiley & Sons.

Hahn, G. J. and Doganaksoy, N. (2011). *A career in statistics: Beyond the numbers*. New Jersey, Hoboken: John Wiley & Sons.

Hamilton, G. (2010). Statistical training for non-statistical staff at the office for national statistics. In *Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8), Ljubljana, Slovenia*. `https://iase-web.org/documents/papers/icots8/ICOTS8_6G3_HAMILTON.pdf`. [Online; accessed April 26, 2019].

Harraway, J. A. and Barker, R. J. (2003). The use of statistics in the workplace: A survey of research graduates in diverse disciplines. In *Proceedings of the 54th Session of the International Statistical Institute, Berlin*. `http://iase-web.org/documents/papers/isi54/3070.pdf`. [Online; accessed April 26, 2019].

Harraway, J. A. and Barker, R. J. (2005). Statistics in the workplace: a survey of use by recent graduates with higher degrees. *Statistics Education Research Journal*, 4(2):43–58.

Hijazi, R. H. (2014). Meeting the demand for statisticians in UAE: Challenges and experiences. *Journal of Economic and Administrative Sciences*, 30(1):45–52.

Hockman, K. K. and Jensen, W. A. (2016). Statisticians as innovation leaders. *Quality Engineering*, 28(2):165–174.

Hole, G., Lee, G., and Jones, T. (1997). The role mathematical statisticians play in three statistical agencies: Australian Bureau of Statistics, Office for National Statistics, UK, and Statistics Canada. In *Proceedings of the 51st Session of the ISI, Bulletin of the International Statistical Institute, LVII, Book*, pages 187–190.

Holmes, P. (1997). Matching education, assessment and employment needs in statistics: The MeaNs project. *Teaching Statistics*, 18:1–3.

Jensen, W., Anderson-Cook, C., Costello, J. A., Doganaksoy, N., Hoerl, R. W., Janis, S., O'Neill, J., Rodebaugh, B., and Snee, R. D. (2012). Statistics to facilitate innovation: A panel discussion. *Quality Engineering*, 24(1):2–19.

Jeske, D. R. and Myhre, J. (2011). Careers in statistics. *International Encyclopedia of Statistical Science*, pages 201–203.

Kettenring, J. R., Koehler, K. J., and McKenzie Jr, J. D. (2015). Challenges and opportunities for statistics in the next 25 years. *The American Statistician*, 69(2):86–90.

Khan, S. (2013). Statistics in planning and development. *Pakistan Journal of Statistics*, 29(4):513–524.

Loynes, R. (1987). *The Training of Statisticians Round the World*. International Statistical Institute. `http://iase-web.org/Books.php?p=book2`. [Online; accessed April 26, 2019].

Nolan, D. and Temple Lang, D. (2010). Computing in the statistics curricula. *The American Statistician*, 64(2):97–107.

Osman, M. and Ismail, M. (2009). What do statisticians working in policy research need from statistical education? In *International Association for Statistical Education Satellite Conference, Durban, South Africa*. `http://iase-web.org/documents/papers/sat2009/9_4.pdf`. [Online; accessed April 26, 2019].

Pantula, S. G. (2011). Statistics: A key to innovation in a data-centric world! *Journal of the American Statistical Association*, 106(493):1–5.

Parcero, O. J. and Ryan, J. C. (2016). Becoming a Knowledge Economy: the Case of Qatar, UAE, and 17 Benchmark Countries. *Journal of the Knowledge Economy*, pages 1–28.

Pierson, S. (2014). Bachelor's degrees in statistics surge another 20%. *Amstat News*, 447:27–28.

Robison, E. L. (2010). Statistical consulting with developing countries on labor force surveys. In *Joint Statistical Meetings, Section on Government Statistics, Vancouver, BC, Canada*.

Romeu, J. L. (2006). Teaching engineering statistics to practicing engineers. In *Proceedings of the 7th International Conference on Teaching Statistics (ICOTS7), Salvador, Bahia, Brazil*. `https://iase-web.org/documents/papers/icots7/4A1_ROME.pdf`. [Online; accessed April 26, 2019].

Ryan, J. C. and Daly, T. M. (2018). Barriers to innovation and knowledge generation: The challenges of conducting business and social research in an emerging country

context. *Journal of Innovation & Knowledge.* (in press).

Sahai, A. and Lovric, M. (2011). Role of statistics. In *International Encyclopedia of Statistical Science*, pages 1254–1258. Springer-Verlag Berlin Heidelberg.

Snee, R. D. (2005). Leading business improvement: A new role for statisticians and quality professionals. *Quality and Reliability Engineering International*, 21(3):235–242.

Statistical Training Institute (2018). STI training calendar 2018: Statistical courses. `https://www.scad.ae/Documents/STI/STI_Calender_English.pdf`. [Online; accessed April 26, 2019].

Stigler, S. M. (2005). Statistics and the wealth of nations. *International statistical review*, 73(2):223–226.

UAE Cabinet (2010). UAE Vision 2021. `http://www.vision2021.ae/en`. [Online; accessed April 26, 2019].

UAE University (2016). Graduates trends 2015-2016. `https://www.uaeu.ac.ae/en/vc/stategy/pdf/graduatescohort36en.pdf`. [Online; accessed April 26, 2019].

UAE University (2017). Statistical year book 2016-2017. `https://www.uaeu.ac.ae/en/vc/stategy/pdf/statisticalyearbook20162017.pdf`. [Online; accessed April 26, 2019].

UAE University (2018). Bachelor of statistics: Degree requirements. `https://cbe.uaeu.ac.ae/en/programs/undergraduate/program_21651.shtml`. [Online; accessed April 26, 2019].

Wasserstein, R. L. (2016). Outlook on statistics leadership. In Amanda L. Golbeck, I. O. and Gel, Y. R., editors, *Leadership and Women in Statistics*, chapter 1, pages 3–8. Chapman and Hall/CRC Statistics Press, Oxford.

Westbrooke, I. and Rohan, M. (2014). Statistical training in the workplace. In *Topics from Australian Conferences on Teaching Statistics*, pages 311–330. Springer, New York, NY.

World Bank (2012). Knowledge Economy Index (KEI) 2012 rankings. `https://knoema.com/atlas/United-Arab-Emirates/topics/World-Rankings/World-Rankings/Knowledge-economy-index`. [Online; accessed April 26, 2019].