

Future Life Expectancy in GCC Countries: Projections with an Extended Lee-Carter Approach

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Received date: 23 February 2018, **Accepted date:** 1 April 2018, **Online date:** 15 April 2018

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Abstract

Mortality and life expectancy rates have changed gradually throughout the past century in many countries all over the world. These changes represent current challenges for governments, actuaries and pension plan sponsors in measuring and managing the longevity risk associated the developments in mortality and life expectancy. On this point, this paper reviews pension plans in Gulf Cooperation Council (GCC) countries and then predicts life expectancy in this region by applying extended Lee-Carter approach. Trends in the mortality rates and life expectancy in GCC countries are identified in order to assist policy makers and actuaries. Furthermore, this paper focuses on assessing the longevity risk associated with the forthcoming changes in life expectancy in the GCC region by 10,000 Monte-Carlo simulations of the extended Lee-Carter model.

Key words: Pension; Longevity risk; Life expectancy projections; Lee-Carter model; GCC Countries.

INTRODUCTION

Longevity risk is the potential hazard of individuals living longer than expected; consequently, it occurs as a result of mortality and life expectancy movements in the future. In order to better understand longevity risk, it is necessary to quantify and study mortality and life expectancy prediction trends. Improvements in longevity are considered most certainly to affect pensions (Barrieue *et al.*, 2012). That is because decreasing mortality rates and improvements in life expectancy have increased the amount of time that pensioners live during their retirement.

According to UN reports (2015), almost 95% of the countries in North America and Europe have reliable, sufficiently accurate and available data for mortality rates, whereas 43% of the countries in Asia have unreliable and missing data for mortality rates. In the case of Gulf Cooperation Council (GCC) countries, which are the Arab countries of the Gulf, namely Saudi Arabia, Oman, Qatar, Bahrain, Kuwait, and the United Arab Emirates (UAE), there are limited time period for age-specific mortality rates data (Winckler, 2009). This is because interest in birth and death statistics only came with the beginning of development and progress in the GCC during the last half-century, and official statistics for death mortality rates have been recorded intermittently. Moreover, the shortage of mortality rates data has occurred due to government policies, which suppress sensitive data (Winckler, 2009). Thus, this paper provides a meaningful view of the developments in mortality and life expectancy in this region. For the purpose of this study, longevity risk or uncertainty associated with forthcoming developments in life expectancy will be discussed.

The paper is structured as follows. Section 2 discusses pension schemes in the GCC region. In section 3, the prediction methodology is discussed. The performance of the extended Lee-Carter model is presented in section 4. In section 5, the risk surrounding projections of life expectancy is discussed. Section 6 presents the concluding remarks.

2. Pension in GCC Countries:

There is pension (public, civil or military, and private pension) schemes in all the GCC countries that are state-managed. The pension sector in GCC countries is relatively new compared with the developed countries. Although there are various pension schemes across the GCC countries, there is significant similarity among them.

The concept of social security (e.g. pensions) is not novel for the Gulf societies; it is deeply rooted in earlier generations because of religious beliefs and cultural traditions. However, official retirement and pension laws in GCC countries were authorized in the later part of the twentieth century. The oldest pension fund is in Saudi Arabia and is only 48 years' old. The pension law in Saudi Arabia was issued in 1969; in both Bahrain and Kuwait, it was in 1976, followed by Oman in 1991, and the newest schemes are as recent as only 17 years (the UAE legislated in 2000) and 15 years (Qatar's was established in 2002). Table 1 shows some comparisons of the characteristics of pension systems in the GCC countries. In this paper, the comparison has been done based on regulatory framework (organization name, sector type, first law for pension, coverage of pension schemes), qualifying conditions for pension (late retirement age, number of years of contribution for full pension, number of years of contribution for early retirement) and contribution rate (employee's share, employer's share, Government's share as % of relevant salary).

In the GCC countries, the pension schemes are compulsory and collective, provide defined benefits and are self-funded by providing benefits in return for contributions collected from the contributors (Sultan, 2002). Pension schemes in the countries of the GCC region are unusual compared with other countries, in that they are funded. This is because the parties (government, employers or employees) that contribute differently to the schemes, from one GCC country to another, and they participate according to their shares, as authorized the law – refer to Sultan (2002) for more details. The income ratios in pension plans in the GCC countries are very generous; e.g. in Saudi Arabia it is 75%, 65% in Kuwait, 80% in both Oman and UAE, 88% in Bahrain, while it is 100% in Qatar.

3. Projection Methodology:

From the literature, a number of new approaches have been proposed throughout the last thirty years for predicting mortality and life expectancy (Luo, 2016). Stochastic models were applied for the purpose of making projections as discussed and reviewed in Alho (1998), Koissi *et al.* (2006), Wang (2007) and Babel *et al.* (2008). Lee & Carter (1992) proposed a model for the prediction of mortality by using singular value decomposition of the observed age-specific mortality. This

has been successfully applied in many developed and developing countries for different time periods (Tuljapurkar *et al.*, 2000; Booth *et al.*, 2002; Renshaw & Haberman, 2003; Wang, 2007; Koissi *et al.*, 2007; Luo *et al.*, 2016). This is because the model has several attractive advantages: the number of parameters is small compared to other stochastic models, the model parameters can be straightforwardly understood and interpreted, and the model's organization offers a steady age pattern of mortality in its projections (Li *et al.*, 2009). Li *et al.* (2004) modified the original Lee and Carter approach to tackle situations in which mortality data is available for limited observations with unequal age-specific intervals. As discussed previously, this problem is fundamental, particularly for GCC countries since there is relatively little documented mortality data. Consequently, this paper has adopted the extended Lee-Carter model (Li *et al.*, 2004) for prediction of future mortality and life expectancy in the GCC region.

Table 1: Comparison of Pension Schemes in GCC Countries

Country	Regulatory Framework				Qualifying Conditions			Contribution Rate		
	Organization/ Agency/ Authority	Sector	First law	Coverage	Late Retirement age	Number of years of contribution for full pension	Number of years of contribution for early Retirement	Employee's share	Employer's share	Government's share
Saudi Arabia	Public Pension Agency (PPA)	Government	1958	<ul style="list-style-type: none"> • Civil • Military 	<ul style="list-style-type: none"> • 60 • According to grade - from Age 44 to age 58 	<ul style="list-style-type: none"> • 40 • 35 (15 years of service with approval) 	<ul style="list-style-type: none"> • 25 (20 years of service with approval) • 15 (8 years of service with approval) 	<ul style="list-style-type: none"> • 9% • 9% 	<ul style="list-style-type: none"> • 9% • 13% 	Any Deficit
	General Organization For Social Insurance (GOSI)	Private	1969	• Civil	• 60	• 40	• 25 (20 years of service with approval)	• 9%	• 9%	
UAE	The General Pension and Social Security Authority (GPSSA)	Government and Private	1999	<ul style="list-style-type: none"> • Civil • Military 	<ul style="list-style-type: none"> • 60 • 60 	<ul style="list-style-type: none"> • 35 • 35 	<ul style="list-style-type: none"> • 15 • 15 	<ul style="list-style-type: none"> • 5% • 2% 	<ul style="list-style-type: none"> • 15% • 15% 	<ul style="list-style-type: none"> • 2.5% • 2.5%
Kuwait	The Public Institution For Social Security (PISS)	Government and Private	1977	<ul style="list-style-type: none"> • Civil • Military 	60/55 (with a contribution period of 15/20 years)	<ul style="list-style-type: none"> • 30 • 27.5 	<ul style="list-style-type: none"> • 15 • 15 	<ul style="list-style-type: none"> • 7.5% • 7.5% 	<ul style="list-style-type: none"> • 11% • 11% 	<ul style="list-style-type: none"> • 10% • 32.5%
Oman	Civil Service Employees Pension Fund (CSEP)	Government	1986	<ul style="list-style-type: none"> • Civil • Military 	<ul style="list-style-type: none"> • 60 • Not available 	<ul style="list-style-type: none"> • 20 • Not available 	<ul style="list-style-type: none"> • 10 • Not available 	• 7%	• None	• 17.7%
	Public Authority For Social Insurance (PASI)	Private	1992	• Civil	• 60/55 (male/ female)	• 20/15 (male/ female)	• 15/10 (male/ female)	• 7%	• 10.5%	• 5.5%
Bahrain	Social Insurance Organization Pension (SIO)	Government	1976	• Civil	• 60/55 with at least 15/10 years of contribution (male/ female)	• 40	• 20/15 (male/ female)	• 6%	• None	• 18%
	Social Insurance Organization Insurance (SIO)	Private	1976		• 60/55 with at least 15/10 years of contribution (male/ female)	• 40	• 20/15 (male/ female)	• 6%	• 9%	• None
Qatar	General Retirement and Social Insurance Authority (GRPA)	Government and private	2002	<ul style="list-style-type: none"> • Civil • Military 	<ul style="list-style-type: none"> • 60 • 60 	<ul style="list-style-type: none"> • 40 • 32 	<ul style="list-style-type: none"> • 15 • 15 	<ul style="list-style-type: none"> • 5% • 5% 	<ul style="list-style-type: none"> • 10% • 10% 	Contributes as an employer and any deficit

Source: Compilation by the author, based on Laws regulating pension issued by GCC countries from PPA, GOSI, GPSSA, PISS, CSEP, PASI, SIO, GRPA (2017); Loewe (2014)

The original Lee-Carter model was introduced by Lee and Carter (1992) as follow:

$$\ln(m_{x,t}) = \alpha_x + \kappa_t \beta_x + \varepsilon_{x,t}, \sum_x \beta_x = 1, \sum_t \kappa_t = 0, \quad (1)$$

Where $m_{x,t}$ the central mortality rate for an age-grouping x during a year t , α_x is the age-specific parameter, representing the average level of mortality at each age x , β_x is the sensitivity parameter, measuring the sensitivity of the log mortality rate to changes in the mortality index κ_t , and $\varepsilon_{x,t}$ is the error term, with the assumption that the mean equals zero and the variance σ^2 .

Li *et al.* (2004) adopted from Lee and Carter (1992) that κ_t follows a random walk with drift, and then obtained all of the Lee-Carter model's parameters by using a few observed $m_{x,t}$, the central death rates at a specified age, x , in times $u(t)$; $t = 0, 1, 2, \dots, T$. Parameters, α_x , are computed as $\alpha_x = \frac{1}{T} \sum_{t=0}^T \log(m_{x,u(t)})$ and the parameters, β_x and $\kappa_{u(t)}$ (for $t = 0, 1, 2, \dots, T$), are obtained by applying the singular value decomposition (SVD). Li *et al.* (2004) deduced that $\kappa_{u(t)}$, can be expressed as:

$$\kappa_{u(t)} - \kappa_{u(t-1)} = \theta_{u(t)-u(t-1)} + \sigma[e_{u(t-1)+1} + \dots + e_{u(t)}] \quad (2)$$

and the estimation of θ is achieved as follows (Li *et al.*, 2004):

$$\hat{\theta} = \frac{\kappa_{u(T)} - \kappa_{u(0)}}{u(T) - u(0)} \quad (3)$$

$$\hat{\sigma}^2 \approx \frac{\sum_{t=1}^T (\kappa_{u(t)} - \kappa_{u(t-1)} - \theta_{u(t)-u(t-1)})^2}{u(T) - u(0) - \left(\frac{\sum_{t=1}^T (u(t) - u(t-1))^2}{u(T) - u(0)} \right)} \quad (4)$$

$$\sqrt{\text{var}(\hat{\theta})} \approx \frac{\hat{\sigma}}{\sqrt{u(T) - u(0)}} \quad (5)$$

After finding the values of $\hat{\theta}$ and $\hat{\sigma}$, the future values of the mortality index and log death rates are performed as:

$$\kappa_t = \kappa_T + \left[\hat{\theta} - \sqrt{\text{var}(\hat{\theta})} \delta \right] (t - T) + \hat{\sigma} \sum_{r=T+1}^t e_r \quad (6)$$

$$\log(m_{x,t}) = \log(m_{x,T}) + \beta_x (\kappa_t - \kappa_T) \quad (7)$$

Assuming that $\delta \sim N(0, 1)$ and $e_r \sim N(0, \hat{\sigma})$ (for $t > T$) are independent.

4. Performance of the LC Model for the GCC Countries:

4.1 Data:

The data used in this paper consists of observed the age group specific mortality rates in GCC countries. Six historical data sets are used in this paper that are freely provided by Global Health Observatory data repository, World Health Organization (WHO) (<http://www.who.int/gho/en/>) and from the national statistics authorities of the GCC countries.

Several authors applied the original Lee Carter for modeling age 25 or 30 onwards, which gives the best results (Wang, 2007; Danesi, *et al.*, 2015). Thus, the analysis in this paper focus on the 30 age groups onwards because these groups cover the public and private participates in pension. Due to the lack of enough data in GCC countries for the very old age groups (those aged more 85), the estimating and forecasting life expectancy is challenging. Thus, in this study for age greater than 85 needed to be compressed into one age group (85-100). Consequently, in this study we have eleven age groups are quinquennial starting from 30 and the last age group is 85-110.

The data is covering the period from 2000 to 2015, considering the following age groups: 30–34 years, 35–39 years, 40–44 years, 45–49 years, 50–54 years, 55–59 years, 60–64 years, 65–69 years, 70–74 years, 75–79 years, 80–84 years, 85-110 years and the extended Lee-Carter approach (Li *et al.*, 2004) to tackle limited observations with unequal age-specific intervals is applied.

4.2 Performing Projections:

In this subsection, corresponding predicted values of life expectancies are computed. Figure 1 demonstrates observed values of life expectancy at different age groups for both genders, with the projections derived. In figure 1, the forecasts the life expectancies for the period 2016 – 2040 in GCC region shows an upward trend in each age group for both genders.

Projections predict a continuous pronounced increase in life expectancy at youngest age groups in all genders in GCC countries; where as in oldest age groups predict a slower increase. For example, for the forecasts of male life expectancy in Oman, for the years, 2020, 2030, and 2040 were 47.3, 48, and 51 respectively in the 30-34 age group; 19.16, 19.98, and 21 respectively in the 60 – 64 age group; and 4.6, 4.67, and 4.73 in the 85+ age group.

Moreover, it can be seen that for all GCC countries the life expectancies at all different ages for females are continuously greater than those for males. In UAE for instance, life expectancy at age 40-43 in 2040 for males is 38.3, whereas it is 41.4 for females. Furthermore, projections for the next 23 years incorporate a slower improvement in life expectancy than in the recent past. This indicates that mortality rates will rise sharply in the next coming years.

5. Discussion of Longevity Risk:

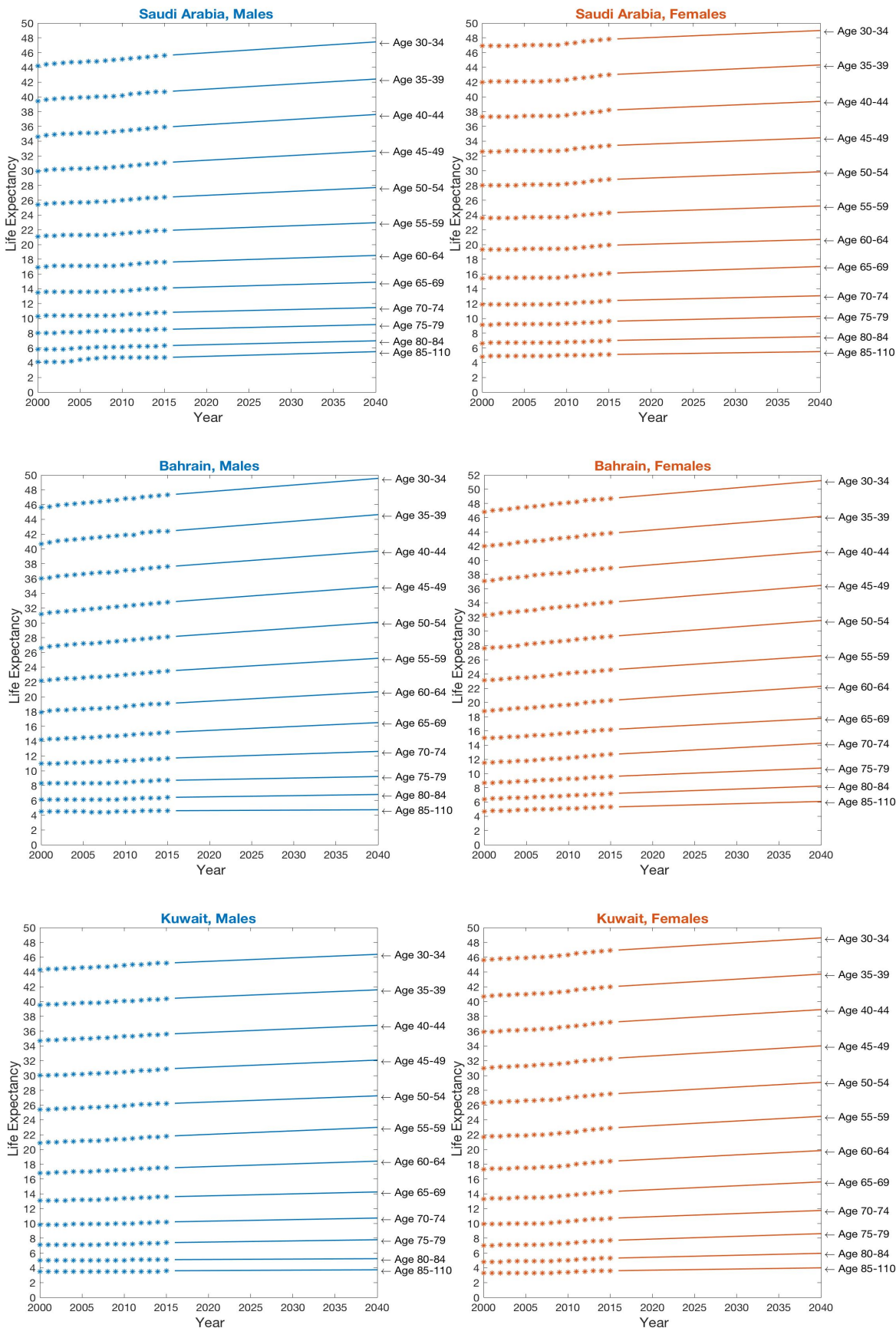
Due to economic issues, pension systems in the GCC region may not be sustainable and capable financial resources. Thus, there need to be deeper views regarding life expectancy projections and the risk surrounding those projections in order to evaluate the amount of pension and then to reform and provide defined pension benefits. The risk or uncertainty that is associated with future progression in life expectancy is defined as longevity risk.

Longevity risk will occur as a result of developments in life expectancy in the upcoming years. Thus, there is a need for an approach to model the risk surrounding life expectancy projections. In this paper, Monte-Carlo simulations can be conducted by repeating the estimated Lee-Carter model 10,000 times using random number producers for the error terms to model the risk corresponding to life expectancy improvements, as discussed by Antolin (2007). He employed frequency distributions and cumulative probabilities generated from 10,000 Monte-Carlo simulations of the Lee-Carter model, which permits the calculation of probabilities for a complete set of projections. Accordingly, risks can be adequately measured (Antolin, 2007).

Figure 2 illustrates the frequency histogram and the cumulative probability for 10,000 Monte-Carlo simulations for life expectancy in 2040 for males in Saudi Arabia at age group 55-59 (pensions providers are more interested in the remaining lifetime for individuals specially after age 55). The cumulative probabilities provide, for each value of life expectancy, the probability of a result that is less than or equal to the correspondingly determined projection (DP) value (Antolin, 2007) that obtained from applying the extended Lee-Carter model as discussed in subsection 4.3. It can be noted from Figure 2 that the DP value lies above the life expectancy (LE) for males in Saudi Arabia. In this regard, the probability is 82% in Saudi Arabia, which means the probability that life expectancy for Saudi males in 2040, will be higher than the determined projection value is less than 50%. Thus, this indicates that there is a 32% probability that life expectancy might rise by more than the determined prediction in this study. Accordingly, the risk around the projections of life expectancy is quite huge. The same results have been concluded for both genders in all GCC countries with different values for the probabilities.

Hence, it is important for governmental pension agencies, providers and actuaries in GCC region to study of life expectancy projections continuously and be aware of the need to measure longevity risk so as measuring its impact on pension schemes when they desire to reform and develop their plans. Additionally, assessing longevity risk can assist in tackling some issues that might arise, such as increased pension liabilities. On the other hand, disregarding the assessment of longevity risk might cause significant instability in the financial condition of governmental pension agencies and providers. The GCC countries can benefit from the more mature countries, such as US and European countries, to design a sufficiently sustainable system with new regulations that effectively overcome

longevity risk issues.



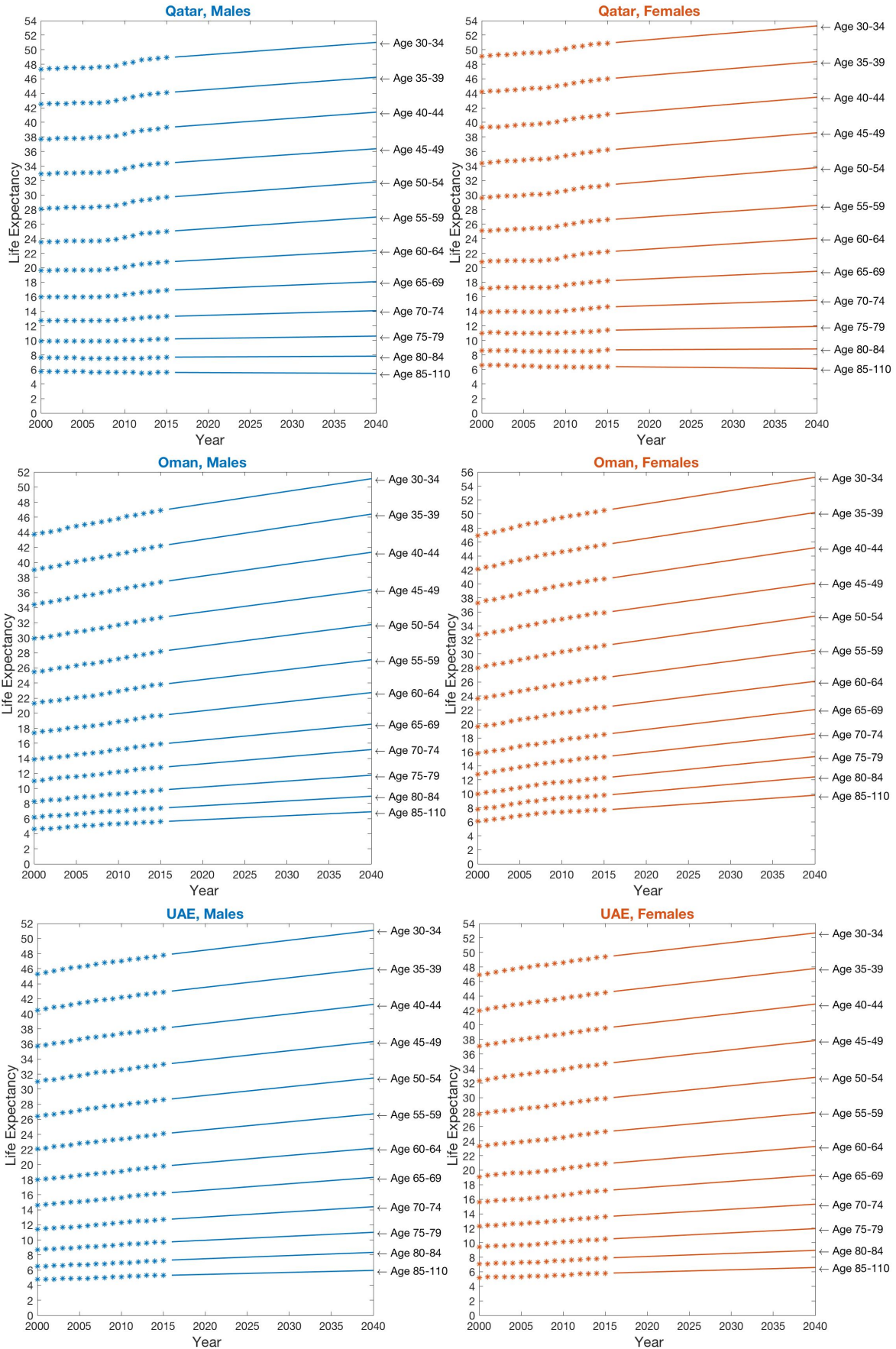


Fig. 1: Observed and Predicted of Life Expectancy Males and Female in GCC Countries. Observed of Life Expectancy for 2000- 2015(starts); predicted of Life Expectancy for 2016-2040 (Solid lines).

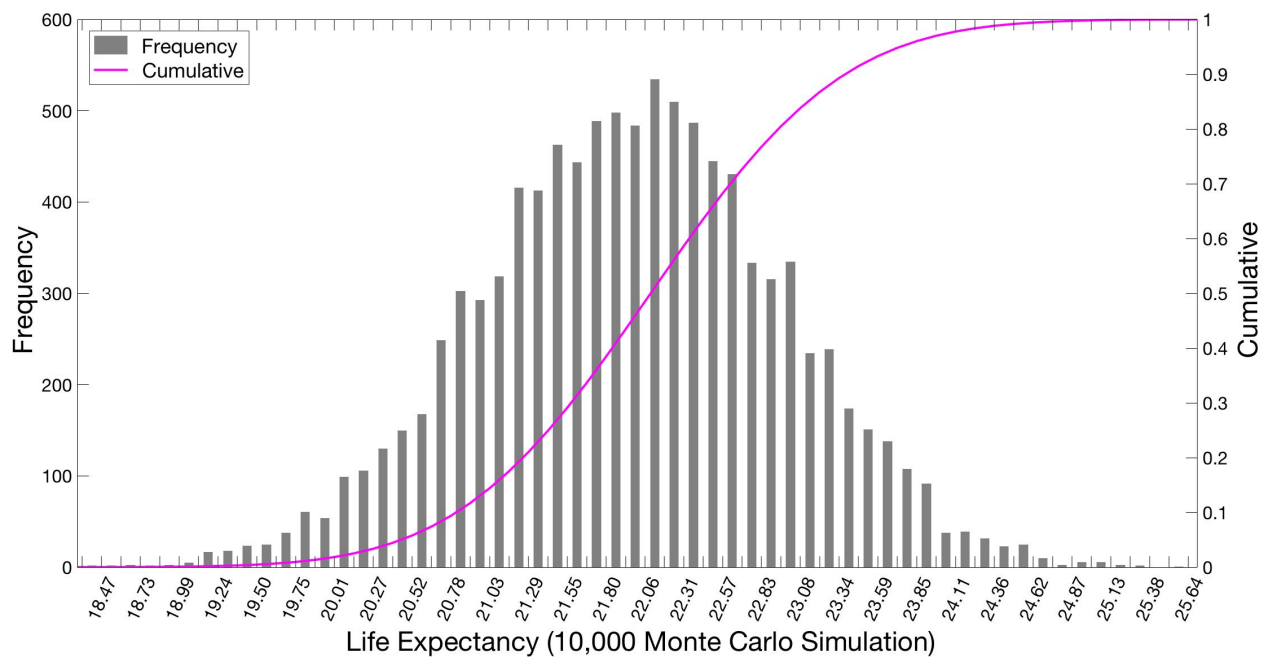


Fig. 2: Simulation of Life Expectancy at Age Group 55-59 in 2040 – Saudi Males.

Conclusion:

To the best of the author's knowledge, this paper offers the first attempt to model longevity risk in the GCC region. This study contributes to the literature on projecting life expectancy. It has estimated the parameters of the extended Lee-Carter model on the basis of missing mortality rates for both genders for a number of periods of time and has attempted to identify the prediction trends in life expectancy in the GCC countries until 2040. Based on the results, it can be stated that there is an upward trend in life expectancy in the countries studied for both males and females; consequently, the mortality trend will decrease.

Furthermore, this paper shows the longevity risk associated with future improvements in life expectancy by generating 10,000 Monte-Carlo simulations of the extended Lee-Carter model. It is notable that future movements in life expectancy indicate that longevity has emerged as a significant risk affecting governmental pension agencies, providers and actuaries in the GCC region. There is a need for further research that focuses on longevity risk in order to adopt new regulations to allow for additional accurate risk management and assessment. In addition, the results hint at the need to obtain new tools to evaluate pension liabilities and obligations. Thus, the impact of longevity risk in the GCC region and the net liabilities of pension schemes beyond their premium periods are significant topics for further research.

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