Mortality Trends of Male Elderly in Malaysia: Comparison between Lee-Carter model and Heligman-Pollard model

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Abstract

Human life expectancies have shown remarkable improvement and this leads to significant reductions in mortality rates across all age groups, genders and countries. In Malaysia, mortality rates have been declined significantly due to the increases of life expectancies of an individual. Thus the proportion of the elderly in Malaysia is increasing. This study examines the mortality trends for male elderly of age group 60-64, 65-69, 70-74 and 75-79. The mortality trends analysis is done by discussing the pattern of mortality rate for the past 35 years period and 10 upcoming years resulted from Lee-Carter Model and Heligman-Pollard Model. Since these models involves nonlinear equations that are explicitly difficult to solve, the Matrix Laboratory (MATLAB) software will be used to estimate the parameters of the models. Autoregressive Integrated Moving Average (ARIMA) procedure is applied to acquire the forecasted parameters for both models as the forecasted mortality rates are obtained by using all the values of forecasted parameters. It was found that the declining trend of mortality in each age group although there is a fluctuation along the past 35 years. However, the estimated mortality rates for both mortality models move along with the actual rate.

Keywords : MortalityTrends; Lee-CarterModel;Heligman-PollardModel; Elderly

I. Introduction

In actuarial field, mortality rate is amongst the most important elements which is needed to formulate insurance products for insurance industry and retirement planning products for retirement planning industry. However, to determine andstudy the mortality rate is not an easy task as it deals with millionsof lives in a country. Census is done to collect the total number of population, death and birth that are used to calculate the mortality rate. In Malaysia, census of population is done by the Department of Statistics, Malaysia and the data is normally presented in the form of five-year-age group.

As years pass by, mortality rates keep on changing parallel with the downward trend as life expectancies tend to increase. Thus, pattern of mortality is needed to find the estimated value of mortality in the future for each individual of certain age. The changes in mortality improvement between years need to be considered due to the long term businesses. It is believed that Malaysia is one of the developing countries that is growing in an ageing population. Samad et al. [1] stated that Malaysian population is ageing due to the increase in life expectancy (reduction of mortality rates), in which Malaysia is forecasted to have an ageing population by 2030 when 15 percent of the total population is elderly. Furthermore, Nor et al. [2] said that number of elderly people age 60 years and above all around the world is expected to increase to 1,968 million in year 2050. This number is based on the increase estimated number of elderly aged 60 years and above over the world from 204 million in year 1950 to 605 million in year 2000.

Haberman [3] identified three changes in the shape of mortality curves which are downward trend,rectangularization and expansion. The first shape is downward trends, which mostly experienced at young and old ages. Rectangularization of the survival function is an increasing concentration of deaths around the average age at death. Last shape of mortality curve is expansion of the survival function which also explained as the average age at death increasing over time. Thus, the study of mortality is useful in determining the prospects of potential changes in population growth and mortality conditions for a country in the future. This study is done mainly to determine the mortality trends of male elderly in Malaysia for the past 35 years period and 10 upcoming years resulted from Lee-Carter Model and Heligman-Pollard Model.

II. Methodology

There are many mortality models that have been introduced and studied by researchers. However, this study only focuses on two mortality models, namely Lee-Carter Model and Heligman-Pollard Model.The model forLee-Carter is probably the best known method for mortality forecasting these days. Lee and Carter [4] proposed a time series model for the time component defined as:

$$\ln\left(m_{x,t}\right) = a_x + b_x k_t + \varepsilon_{x,t} \tag{1}$$

where $m_{x,t}$ represents the central mortality rate of age x at time t ; a_x is the average log-mortality of age x ; b_x measures the response of age x to change in k_t ; k_t represents the overall level of mortality at time t and $\varepsilon_{x,t}$ is the error term or residual.

Heligman and Pollard [5] proposed a parameterisation function model that consists of eight parameters defined as:

$$\frac{q_x}{p_x} = A^{(x+B)^C} + D\exp\left[-E\left(\ln\left(\frac{x}{F}\right)\right)^2\right] + GH^x \tag{2}$$

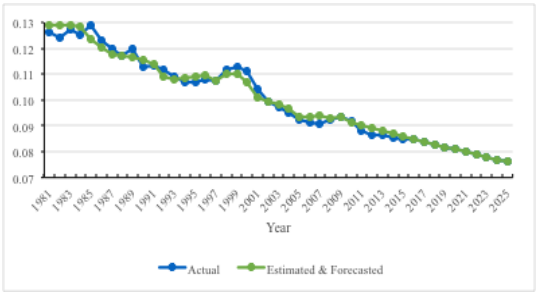
where q_x is the probability that an individual who has reached age x will die before reaching age $x+1$; $p_x = 1-q_x$ and A, B, C, D, E, F, G, H are the eight positive parameters to be estimated by using non-linear weighted least squares methods.Since model (1) and model (2) involves nonlinear equations that are explicitly difficult to solve, the

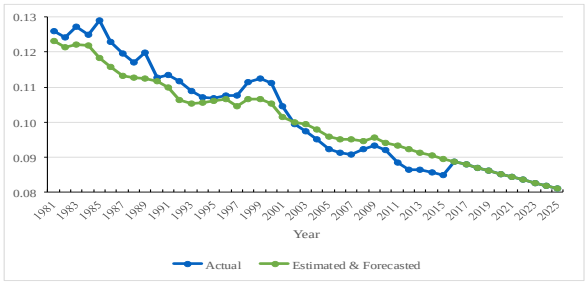
Matrix Laboratory (MATLAB) software is used to estimate the parameters of the models. The details of method for both models can be referred to Ibrahim et al. [6] and Ibrahim [7].

To analyse the mortality trends for male elderly in Malaysia for the past 35 years, the abridged life table from year 1981 to 2015 will be required. In the study, the desired data from abridged life table is only ${}_nq_x$. The empirical data sets of male elderly, people of ages 60 years old and above for the period of 1981 to 2015 are considered, which the period of 1981 to 2010 are used as "training set" and year 2011 to 2015 as "testing set". The "training set" consists of 30 years historical data that is used to estimate the parameters for both mortality models by fitting to its mortality rates while the "testing set" is the period in which the assessment of the performance for both models are done. The estimated of the forecasted mortality rates for year 2011 to 2015 are compared against actual data to investigate the accuracy of the projection. Then, the forecasted parameters are obtained using ARIMA procedure. After forecasting each of the parameters, all forecasted parameters are substituted back into equations (1) and (2) to obtain the forecasted mortality rates for 10 upcoming years. The analysis of this study is done by age group of 60-64, 65-69, 70-74 and 75-79.

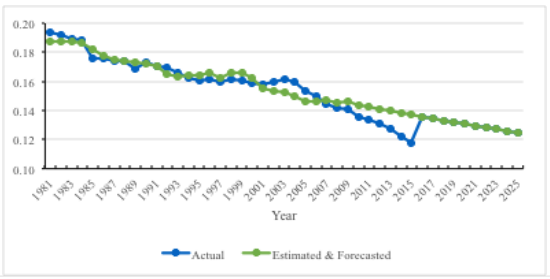
III. Results and Discussion

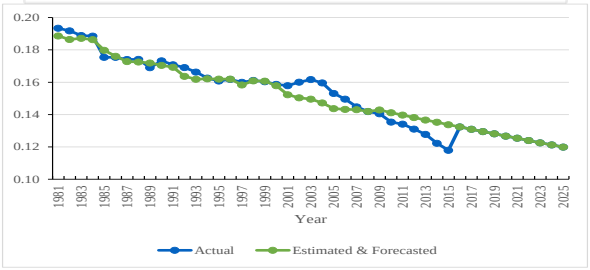
The analysis of mortality trends is done by discussing the pattern of mortality rate for the past 35 years and 10 upcoming years resulted from Lee-Carter Model and Heligman-Pollard Model. The estimated value is plotted with the actual data to check whether the model fits and moves along with the actual data. Moreover, the forecasted result is also plotted and the discussion is done by age group for each mortality model. Figure 1 shows the mortality trends for the past 35 years and 10 upcoming years resulted from Lee-Carter Model and Heligman-Pollard Model for age group of 60-64, 65-69, 70-74 and 75-79. It was found that the estimated mortality rates seem to move along with the actual value for both mortality models although the actual rates seem to fluctuate year by year for each age group. Also the result shown that the mortality rate for male elderly seems to increase as age increases. This can be seen as in each age group, the actual values in year 1981 are around 0.12602, 0.19341, 0.27243 and 0.39801. The mortality rates tend to decrease generally as in year 2015, the mortality rates for male in the age group of 60-64, 65-69, 70-74 and 75-79 are around 0.08485, 0.11795,0.19573 and 0.27927 respectively. The decrement value from year 1981 to 2015 was recorded about 0.0412, 0.0755, 0.0767 and 0.1187 for each age group.



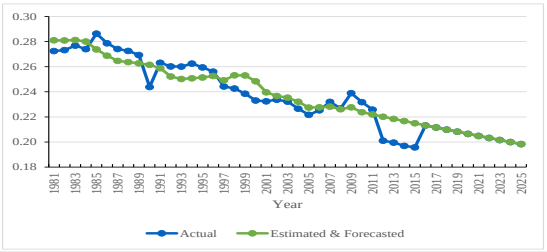


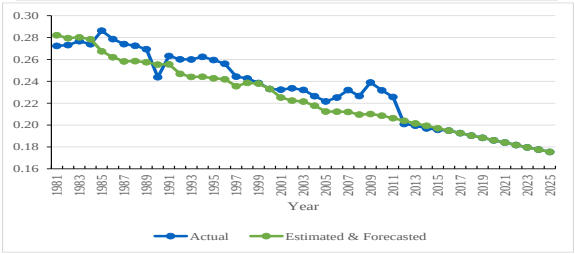
(a) Lee-Carter Model (Age Group 60-64) (a) Heligman-Pollard Model (Age Group 60-64)



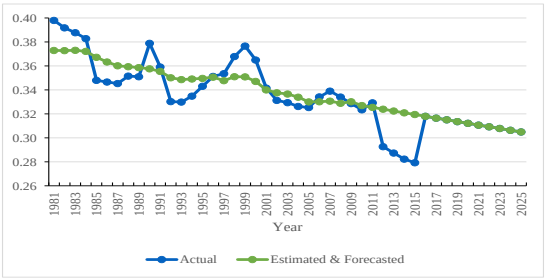


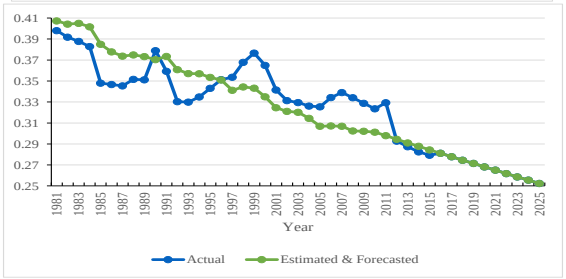
(b) Lee-Carter Model (Age Group 65-69) (b)Heligman-Pollard Model (Age Group 65-69)





(c) Lee-Carter Model (Age Group 70-74) (c) Heligman-Pollard Model (Age Group 70-74)





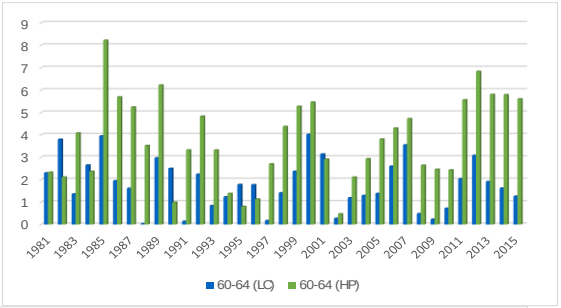
(d) Lee-Carter Model (Age Group 75-79) (d) Heligman-Pollard Model (Age Group 75-79)

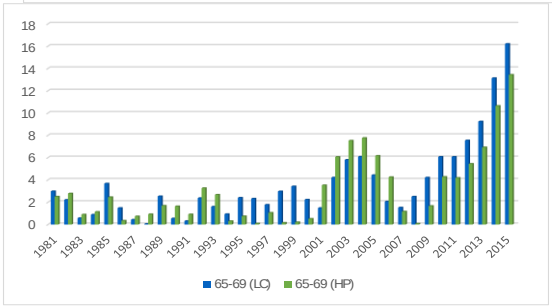
Fig. 1. Mortality Rates of Lee-Carter Model and Heligman-Pollard Model for Male Elderly

In addition, it was clearly seen thatthe forecasted rates tend to decrease continuously in all age groups.The forecasted mortality rate for age group 60-64, 65-69, 70-74 and 75-79 resulted from Lee-Carter Model are expected to decline to 0.07614, 0.12477, 0.19835 and 0.30500 respectively in year 2025 while 0.08101, 0.11990, 0.17552 and 0.25244 for Heligman-Pollard Model as depicted in Figure 1. The decrement value for

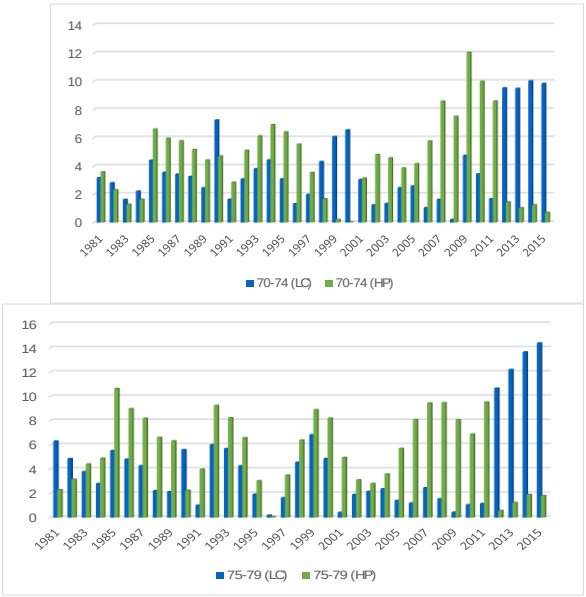
each age group from year 1981 to 2025 are around 0.04988, 0.06864, 0.07408 and 0.09301 resulted from Lee-Carter Model while for 0.04501, 0.07351, 0.09691 and 0.14557 for Heligman-Pollard Model. It can be seen that the decrement value increases as age group increases.

To compare the estimated results of Lee-Carter Model and Heligman-Pollard Model with actual values in year 1981 to 2015 for each age group, the analysis of percentage different between actual values and estimated values is done. The results are presented in Figure 2.





(a) Age Group 60-64 (b) Age Group 65-69



(c) Age Group 70-74 (d) Age Group 75-79

Fig. 2. Percentage Different between Actual Values and Estimated Values in year 1981 to 2015

From Figure 2(a), it was found that Lee-Carter Model fits very well to the actual data compared to Heligman-Pollard Model for age group 60-64. Also, the study found that for age group of 65-69, both models fits very well to the actual data until year 2000. Then starting year 2001 until 2007, it was found that Lee-Carter Model fits well to the actual data compared to Heligman-Pollard Model and after year 2007 Heligman-Pollard Model seems to fit well to the actual data compared to Lee-Carter Model as shown in Figure 2(b). In addition, for age group of 70-74 and 75-79**,** it was clearly shown that Lee-Carter Model seems to fit very well to the actual data compared to Heligman-Pollard Model until year 2011 and after that it was found that Heligman-Pollard Model fits well to the actual data compared Lee-Carter Model. However, comparing their overall fits, it was summarized that both models seem to fit the actual data becausethe estimated mortality rates seem to move along with the actual value for the past 35 years.

IV. Conclusion

The purpose of this study is to examine the mortality trends of male elderly in Malaysia for the past 35 years and 10 upcoming years resulted from Lee-Carter Model and Heligman-Pollard Model for age group of 60-64, 65-69, 70-74 and 75-79. Nonlinear equations from the models are estimated using MATLAB software. All the results are displayed graphically in terms of mortality rates for both models and percentage different between actual values and estimated values. Based on the results, it can be concluded that the estimated mortality rates seem to move along with the actual value for both mortality models although the actual rates seem to fluctuate year by year for each age group. Also the mortality rate of male elderly in Malaysia

increases as age increases for both mortality models. In addition, the declining trends of mortality is projected to continue in the future where the mortality rates projected had decline continuously for male elderly in Malaysia.

V. Acknowledgement

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