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Analysis of Mortality Improvement on the Pension Cost Due to Aging Population

Rose Irnawaty Ibrahim* **and Norazmir Mohd Nordin**

Department of Business Administration
Faculty of Science and Technology
Universiti Sains Islam Malaysia (USIM)
71800 Bandar Baru Nilai, Negeri Sembilan, Malaysia

*Corresponding author: rose.irnawaty@usim.edu.my

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Abstract Aging is a good indicator in demographic and health areas as the lifespan of the elderly population increases. Based on the government's Economic Outlook 2019, it was found that an aging population would increase the government pension payments as the pensioners and their beneficiaries have longer life expectancy. Due to mortality rates decreasing over time, the life expectancy tends to increase in the future. The aims of this study are to forecast the mortality rates in the years 2020 and 2025 using the Heligman-Pollard model and then analyse the effect of mortality improvement on the pension cost (annuity factor) for the Malaysian population. However, this study only focuses on estimating the annuity factor using life annuities through the forecasted mortality rates. The findings indicated that the pension cost is expected to increase if the life expectancy of the Malaysian population increases due to the aging population in the near future. Thus, to reduce pension costs and help the pensioners from insufficient financial income, the government needs to consider an extension of the retirement age in future.

Keywords Aging; mortality improvement; pension cost; Heligman-Pollard model; life annuities.

Mathematics Subject Classification 62P05

1 Introduction

Population aging is becoming a key global challenge to the fiscal and macroeconomics stability of many societies through increased government spending on pension, health care, and social benefits programs for the elderly. Aging is a term that refers to the population of a country getting older. A common definition of aging is the cut-off age of '60 years and over'. Another definition refers to those over the retirement age, which is usually measured by the age at

which a person is eligible for pension [1]. In Malaysia, older people are defined as those who are 60 years and above. According to the Malaysian Healthy Aging Society (MHAS) president, Professor Dr Philip George, Malaysia is also inevitably moving towards an ageing population as those aged 60 years and above have grown from 6.2% in 2000 and it is expected to hit 13.6% by 2030. In the face of an aging population, people are living longer today than ever before, thus the ratio of workers to pensioners is getting smaller. The decline in the ratio of workers to pensioners will cause a significant burden to those who are still working. In general, these aging populations not only have significant impact on individuals, but also affect insurers, employer pension funds as well as society in general. One way to overcome this problem is to increase the retirement age and inevitably, this will allow people to retain their jobs.

It is well known that Malaysia and other countries are facing challenges in the wake of these demographic changes, which are supported by longevity risk. Longevity risk is the risk that individuals live longer than expected, with the consequent being a shortage of incomes. The future uncertainty of lifetime will increase serious financial threats to individuals, employers who sponsor defined benefit pension funds and governments. Based on the government's Economic Outlook 2019 [2], it was discovered that an ageing population would increase the government pension payments as the pensioners and their beneficiaries have longer life expectancies. Given that the number of pensioners is rising due to the increase in the expected life expectancy of the population, especially the pensioners and their beneficiaries, pension payments tend to increase dramatically. However, there is uncertainty over expectations of future life expectancy or how an individual is healthy during their retirement and ultimately, how to cater the costs for their growing needs.

Many studies found that the life expectancy in most countries keeps increasing year by year. Since the life expectancy tends to increase over time, the rate of mortality tends to be smaller in the future. Thus, it is expected that pensioners and their beneficiaries are able to live longer and indirectly, this will result in higher pension costs to the government. The latest World Health Organization (WHO) data published in 2018 found that the life expectancy for male in Malaysia is 73.2 and female is 77.6 [3]. A study from [4] found that the mortality rates for both males and females in Malaysia had decreased steadily from year 1970 until 2010. This finding is supported by Bujang *et al.* [5] where the trends of mortality for Malaysian populations have been declining from 1995 until 2010. In view of this, the forecasting mortality rates have become a concern and a growing interest for professionals. Actuaries, demographers and researchers have been playing important roles in forecasting mortality rates for the benefits of insurance and pension industries as well as other fields. There are several methods that have been discussed in previous studies to forecast mortality rates [6–12]. One of the well-known methods is the Heligman and Pollard model. As mentioned by many researchers, this model is the best mortality model ever available at all ages and it is also an effective way to generate a specific mortality rate for population projection [6, 8, 10]. Therefore, in order to forecast future mortality rates for this study, the Heligman and Pollard model will be used. However, the main purpose of this study is to analyze the effect of mortality improvement on the pension cost (annuity factor) for Malaysian population in the years 2010, 2015, 2020 and 2025.

The structure of this paper is as follows. Section 1 presents a brief overview and literature of the study. Section 2 describes the methodology adopted in this study. Mortality model such as the Heligman-Pollard model and life annuities are explained in this section. Section 3 presents the results and discussion of the study. Lastly, Section 4 concludes with the main findings and

some policy implications.

2 Methodology

2.1 Heligman-Pollard model

To forecast the rates of mortality for the Malaysian population in the years 2020 and 2025, the parameters for the Heligman-Pollard model need to be estimated first as discussed by Ibrahim *et al.* [6]. The empirical data sets of Malaysian population for the period of 1981 to 2015 for both genders will be considered in the study. Heligman-Pollard model is an eight-parameter parameterisation function that draws an age pattern of mortality [13]. The model equation is as follows:

$$\frac{q_{x,t}}{p_{x,t}} = A_t^{(x+B_t)^{C_t}} + D_t \left\{ \exp\left\{ -E_t \left[\ln\left(\frac{x}{F_t} \right) \right]^2 \right\} \right\} + G_t H_t^x, \tag{1}$$

where $q_{x,t}$ refers to probability that a life age x will die within one year, in year t, while $p_{x,t} = 1 - q_{x,t}$ and A, B, C, D, E, F, G and H are the positive parameters to be estimated. Matrix Laboratory Version 8.0 (MATLAB 8.0) will be used to estimate the parameters of this model as this model involves non-linear equations that are obviously difficult to solve. The forecasted parameters are obtained by using the Autoregressive Integrated Moving Average (ARIMA) procedure and then the forecasted parameters are plugged back into equation (1) to obtain the forecasted mortality rates in the years 2020 and 2025 respectively. The Autoregressive Integrated Moving Average (ARIMA) procedure is applied to acquire the forecasted parameters for the Heligman-Pollard model as the forecasted mortality rates are obtained by using all the values of the forecasted parameters in the Heligman-Pollard model.

2.2 Life Annuities

In this study, the cost of pension will be estimated using life annuities. As mentioned by Neill [14], Jordon [15] and Hooker [16], life annuities are a series of payments at fixed intervals, paid while the individual is still alive, known as single life annuity. In practice, an annuity ends with the death of the individual, but it can be designed to pay during the lives of more than one person, where it is called as a joint life annuity. This study considers two types of commutation functions for single life and joint lives with an interest of 3% per annum as follows:

$$\text{(i)}\ \ D_x = v^x l_x \qquad \text{(ii)}\ \ N_x = \sum_{t=0}^{\infty} D_{x+t} \qquad \text{(iii)}\ \ D_{xy} = v^{0.5(x+y)} l_{xy} \qquad \text{(iv)}\ \ N_{xy} = \sum_{t=0}^{\infty} D_{x+t:y+t},$$

where, D_x and N_x are the commutation functions for single life, D_{xy} and N_{xy} are the commutation functions for joint lives and l_{xy} is the expected number of joint life who will survive to age $x+1$ and $y+1$.

From the theory of annuities, the present value of RM1 per year payable m times at the end of each year to a life aged x is denoted by $a_x^{(m)}$, and can be written as

$$a_x^{(m)} = a_x + \frac{m-1}{2m}.$$

A joint life annuity payable to a life aged y, m times a year and commencing at the end of the year that a life aged x dies is denoted by $a_{x/y}^{(m)}$, can be formulated as

$$a_{x/y}^{(m)} = a_y^{(m)} - a_{xy}^{(m)} = \left(\frac{N_{y+1}}{D_y} + \frac{m-1}{2m}\right) - \left(\frac{N_{x+1:y+1}}{D_{xy}} + \frac{m-1}{2m}\right).$$

However, under the Malaysian Government Pension Scheme, the payments of pension are usually made on a monthly basis and are payable at the end of the month. In view of the annuity factor, we can say that there is RM1 of monthly pension. Thus the annuity factor (AF) for pensioner who choose to retire at age x can be expressed as follows:

$$\begin{aligned} AF(p) &= a_x^{(12)} \\ &\cong a_x + \frac{11}{24} \\ &\cong \frac{N_{x+1}}{D_x} + \frac{11}{24}. \end{aligned} \tag{2}$$

Since the derivative pension will be paid at a rate of 100% throughout the period of eligibility starting from 1 January 2009, the annuity factor (AF) for a spouse age y of a pensioner who choose to retire at age x can be expressed as follows:

$$\begin{aligned} AF(s) &= a_{x/y}^{(12)} \\ &= a_y^{(12)} - a_{xy}^{(12)} \\ &\cong \left(\frac{N_{y+1}}{D_y} + \frac{11}{24}\right) - \left(\frac{N_{x+1:y+1}}{D_{xy}} + \frac{11}{24}\right). \end{aligned} \tag{3}$$

The children also are eligible for the derivative pension until age 21 years or until 1st Degree. However, this study only focuses on the effect of pension cost for the pensioner and their spouse.

3 Results and Discussion

In this study, the effect of mortality improvement on the pension cost (annuity factor) for the Malaysian population in the years 2010, 2015, 2020 and 2025 are investigated. Since the focus of this study is to analyze the mortality risk for pensioners, the ages that have been considered for sensitivity testing purpose are 55, 58, 60, 62 and 65.

3.1 Estimated Annuity Factor for Pensioner

The estimated annuity factor for both male and female pensioners have been calculated using equation (2). The summary of the estimated results is presented and discussed below.

According to Table 1, it was found that, as age increases, the estimated annuity factor for both male and female pensioners decrease. This means that if government increases retirement age, the pension costs to the government can be reduced. Besides that, increasing the retirement age will increase the size of the active labour force relative to the number of pensioners. Also, we can see clearly that the estimated annuity factor for female pensioners is always greater

Table 1: Summary of Estimated Annuity Factor for Male and Female Pensioners in the Years 2010, 2015, 2020 and 2025.

Male Pensioners					**Female Pensioners**			
Age	**2010**	**2015**	**2020**	**2025**	**2010**	**2015**	**2020**	**2025**
55	15.2082	15.6184	15.6938	16.0871	16.8338	17.2361	17.7151	17.7151
58	14.0198	14.4487	14.5262	14.9341	15.5850	16.0356	16.4968	16.4968
60	13.2229	13.6624	13.7410	14.1568	14.7333	15.2167	15.6613	15.6613
62	12.4264	12.8749	12.9542	13.3763	13.8707	14.3868	14.8109	14.8109
65	11.2413	11.6994	11.7791	12.2072	12.5660	13.1295	13.5160	13.5160

than male pensioners since the life expectancy of women is much higher than that of men. In addition, it can be seen that the estimated annuity factor for both male and female pensioners increase as the year increases, reflecting the decreasing effect of mortality improvements as the year increases. These finding indicate that the pension costs will increase in the future if the effect of mortality improvements due to aging population is addressed.

3.2 Estimated Annuity Factor for Spouse

The estimated annuity factor for spouse of both male and female pensioners also have been calculated using equation (3). This study only focuses on the case of the spouse of male pensioners who is 0, 3 or 5 years old younger than her husband and spouse of female pensioners who is 0, 3 or 5 years old older than his wife. A summary of the results obtained is shown in Table 2.

Based on Table 2, the estimated annuity factor for the spouse of both male and female pensioners decreased as the age increased for all age gaps. This indicates that the pension cost will decrease as age increases. This means that in order to reduce the financial burden shouldered by the government, it needs to increase the retirement age in the future. Also, it was found that the estimated annuity factor for the spouse of male pensioners is always greater than that of female pensioners since the life expectancy for the spouse of male pensioners is much higher than that of female pensioners. Furthermore, it can be seen that the estimated annuity factor for the spouse of both male and female pensioners increase as the year increases, reflecting the effect of decreasing mortality improvements as the year increases. This indicates that the decline in mortality rates caused by population aging leads to an increase in pension expenditure in the future.This means that pension costs will increase in the future if the effect of mortality improvements due to aging population is addressed. Therefore, one of the ways to reduce pension costs to the government and at the same time to help the pensioners from insufficient financial income, is for the government to consider increasing the age of retirement in the future with respect to an aging population.

Table 2: Summary of Estimated Annuity Factor for Spouse of Male and Female Pensioners in the Years 2010, 2015, 2020 and 2025.

Spouse of male pensioner is same age with her husband					**Spouse of female pensioner is same age with his wife**			
Age	**2010**	**2015**	**2020**	**2025**	**2010**	**2015**	**2020**	**2025**
55	16.1419	16.5439	17.0224	17.0225	14.5162	14.9263	15.0013	15.3655
58	14.9182	15.3685	15.8291	15.8293	13.3530	13.7817	13.8587	14.2338
60	14.0817	14.5648	15.0087	15.0089	12.5713	13.0105	13.0886	13.4687
62	13.2332	13.7489	14.1723	14.1726	11.7890	12.2371	12.3159	12.6990
65	11.9480	12.5109	12.8966	12.8969	10.6233	11.0809	11.1601	11.5432
Spouse of male pensioner is 3 year older than her husband					**Spouse of female pensioner is 3 year younger than his wife**			
Age	**2010**	**2015**	**2020**	**2025**	**2010**	**2015**	**2020**	**2025**
55	16.1550	16.5570	17.0354	17.0356	14.5294	14.9394	14.9946	15.3785
58	14.9299	15.3802	15.8407	15.8409	13.3648	13.7933	13.8481	14.2454
60	14.0926	14.5756	15.0195	15.0198	12.5822	13.0214	13.0752	13.4795
62	13.2434	13.7590	14.1823	14.1827	11.7992	12.2472	12.2994	12.7091
65	11.9572	12.5201	12.9057	12.9061	10.6326	11.0900	11.1384	11.5523
Spouse of male pensioner is 5 year older than her husband					**Spouse of female pensioner is 5 year younger than his wife**			
Age	**2010**	**2015**	**2020**	**2025**	**2010**	**2015**	**2020**	**2025**
55	16.1634	16.5654	17.0438	17.0440	14.5378	14.9477	15.0029	15.3868
58	14.9374	15.3877	15.8481	15.8484	13.3723	13.8008	13.8556	14.2528
60	14.0996	14.5826	15.0264	15.0267	12.5892	13.0284	13.0821	13.4865
62	13.2500	13.7656	14.1888	14.1892	11.8058	12.2537	12.3059	12.7155
65	11.9633	12.5260	12.9116	12.9121	10.6386	11.0960	11.1443	11.5581

4 Conclusion

Due to aging population, the life expectancy at a certain age tends to increase over time. Thus, it is expected that pensioners and their beneficiaries tend to live longer and thereby cause an increase in pension costs to the government in the future. The higher life expectancy of the population, especially pensioners and their beneficiaries, tends to increase pension payments. Therefore, the current pension scheme may not be sustainable in the long run as it will pose a

large financial burden on the government's fiscal position. As such, the government should seek ways to reform its pension systems in anticipation of fiscal burdens in the future. One solution for the government to consider is increasing the retirement age of their employees or introduces the effective retirement age in the future. In addition, we hope that the method used in this study and the findings could be used as a guideline and reference to the government or other pension industries in setting up a new government pension policy in the future if they intend to reduce the future pension costs as the life expectancy of the Malaysian population increases due to the aging population.

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