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ANALYSIS OF CHANGES IN TOTAL ACTUARIAL LIABILITIES USING PROJECTED UNIT CREDIT METHOD

(Analisis Perubahan dalam Jumlah Liabiliti Aktuari Menggunakan Kaedah Unit Kredit Unjuran)

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ABSTRACT

Malaysia is projected to become an ageing country by the year 2030 with the increase in population of older people to be over 15.3%. It is affecting the government expenditure in the sustainably of providing retirement benefits to older people. This study will analyse the changes of actuarial assumptions in total actuarial liabilities of a specific group of government employees. A data set is collected from a group of government employees in a Malaysian public university under service grade of N (Administration & Support). The total actuarial liability will be calculated using the Projected Unit Credit method and actuarial assumptions such as the retirement age, mortality rate, interest rate and salary growth rate will be considered. The study found that when the retirement age is increased, the total actuarial liabilities would decrease which is the aim of a sustainable pension system. Meanwhile, the decreasing mortality rate due to population ageing will cause the total actuarial liabilities to increase. Lastly, when interest rate is high and salary growth rate is lowered, the pension system is getting better. In conclusion, it is necessary for Malaysian government to take early action to sustain the Malaysian pension system due to the occurring population ageing.

Keywords: actuarial liabilities; projected unit credit; pension; population ageing

ABSTRAK

Malaysia diunjurkan menjadi negara menua menjelang tahun 2030 dengan pertambahan populasi warga emas melebihi 15.3%. Ia menjejaskan perbelanjaan kerajaan dalam menyediakan faedah persaraan secara mampan kepada warga emas. Kajian ini menganalisis perubahan andaian aktuari dalam jumlah liabiliti aktuari bagi kumpulan kakitangan kerajaan tertentu. Satu set data dikumpul daripada sekumpulan kakitangan kerajaan di universiti awam Malaysia di bawah gred perkhidmatan N (Pentadbiran & Sokongan). Jumlah liabiliti aktuari dikira menggunakan kaedah Unit Kredit Unjuran dan andaian aktuari seperti umur persaraan, kadar kematian, kadar faedah dan kadar pertumbuhan gaji dipertimbangkan. Kajian mendapati apabila umur persaraan dinaikkan, jumlah liabiliti aktuari akan berkurangan di mana ia merupakan matlamat sistem pencen yang mampan. Sementara itu, penurunan kadar kematian akibat penuaan populasi akan menyebabkan jumlah liabiliti aktuari meningkat. Akhir sekali, apabila kadar faedah tinggi dan kadar pertumbuhan gaji diturunkan, sistem pencen semakin baik. Kesimpulannya, kerajaan Malaysia perlu mengambil tindakan awal untuk mengekalkan sistem pencen Malaysia berikutan penuaan populasi yang semakin meningkat.

Kata kunci: liabiliti aktuari; unit kredit unjuran; pencen; penuaan populasi

1. Introduction

Population ageing is defined as when the country's population distribution is moving towards older age caused by the increase of life expectancy and decline in total fertility rate. Malaysia is projected to become an ageing country by year 2030; as the Malaysian population over 60 years old and above will be over 15.3%. In 2020, the Malaysian population of age 60 years old and above has increase to 10.7 percent from 10.3 percent in the previous year, 2019

(Department of Statistics Malaysia 2021). With this type of increment every year, there is no doubt that Malaysia will shift to be an ageing country by year 2030. The pension system in a developed country may encounter a financial sustainability problem caused by the population ageing (Serrano *et al.* 2011). The government pension expenditures and general provident funds (a proxy to pension liabilities) are significantly affected by the increasing of old-age dependency ratio and the average life expectancy in both long-run and short-run period (Wahab *et al.* 2017). In view of this, it is important to analyse the changes on total actuarial liabilities for a specific group of government employees using the Projected Unit Credit method.

According to Hikmah (2018), the actuarial liabilities of the participants grow for each period as the working time increases. It appears that the increasing age of the participant will lead the participant actuarial liabilities that must be owned by the Pension Fund to be increased. Bielecki *et al.* (2016) notifies that when there is a decline in mortality rates in pension members, it will affect the pension scheme. This is due to the circumstances where when the mortality rate decreases, pensioners are likely to have longer lives. This leads to an increment in benefit paid to the member while the contributions stay the same (Ibrahim *et al.* 2021). In addition, the actuarial interest rate also can be used to determine how much money is needed to be invested in the present to be able to pay out the retirement commitments in the future. Setting a higher actuarial interest rate will not enhance a retirement fund's financial status (De Nederlandsche Bank n.d.). Furthermore, if these assets are used now at a higher actuarial interest rate, there will be insufficient assets left for upcoming generations. Besides, salary growth of a participant will affect the actuarial liability as the salary growth indicator is used in the formula of to measure the actuarial liability (Woerheide 1995).

There are several actuarial cost methods that are used by actuaries to estimate the value needed by a firm to fund its pension expenses on a regular basis. Usually, there are two types of approaches that are used in calculating the pension payments; which are the cost approach such as Entry Age method and Aggregate method, and the benefit approach such as Unit Credit method and Projected Unit Credit method (Chen 1995). In this study, the Projected Unit Credit (PUC) method is utilized as Chen and Matkin (2017) found that when comparing the PUC and Credit Unit methods, that there is a slight minimal effect of choosing a different cost method on the retirement cost under median condition. The perk of using the PUC method is that the pension costs for the PUC method do not growing as quickly as the unit credit method (Hussein 2019). The PUC method considers future salary increases when calculating the actuarial liability.

2. Material and Method

2.1 *Data collection*

A set of secondary data from a Malaysian public university consists of 359 employees under the service grade N is used for this study. The information collected, such as employee age, year of services, salary and retirement age. In Malaysia, grade N in the government sector is also known as the administrative and support services.

2.2. *Projected unit credit method*

To calculate the actuarial liability, this method considers future salary increases. Considering a retirement fund valuation at time 0 for a participant who is age x at time 0, the annual

retirement benefit which has been earned starting at age e to age x is usually a certain number of dollars every month per every service year.

According to Kotamaki (2013), the pension benefits of an individual at age of valuation x is $B_x = k \times S_{r-1} \times (x-e)$. By assuming the final salary as $S_{r-1} = \left(\frac{S_{r-1}}{S_x}\right) S_x$, so that

$$B_x = k \times \left(\frac{S_{r-1}}{S_x}\right) S_x \times (x-e) = k \times \left(1+S\right)^{r-1-x} S_x \times (x-e) \tag{1}$$

where, k is percentage of the pension benefits and S is percentage of salary increases.

The actuarial liability at age x is the value of the retirement benefit earned starting at age e to age x. It is presented by;

$$AL_x = B_x \frac{D_r^{(\tau)}}{D_x^{(\tau)}} \ddot{a}_r^{(12)} \tag{2}$$

where, $\frac{D_r^{(\tau)}}{D_x^{(\tau)}}$ is computed from a service table.

If number of active participants is N, total actuarial liability (TAL) for all active participants in a retirement plan is calculated by adding the individual liabilities for each active participant, which can be stated as follows;

$$TAL = \sum_{x}^{N} k \times \left(1+S\right)^{r-1-x} S_x \times (x-e) \frac{D_r^{(\tau)}}{D_x^{(\tau)}} \ddot{a}_r^{(12)} \tag{3}$$

2.3. *Sensitivity analysis*

For this study, the model allows several scenarios to be formed. The scenarios are as follow:

- Baseline Scenario: The age of retirement is at 56 years old, mortality rate is based on the year 2020, interest rate is 5% and salary growth is at 6%.
- Scenario 1: The variable that will be manipulated is retirement age while the other variables are remain constant. Retirement age is assumed to be 58, 60 and 62 years old.
- Scenario 2: The variable that will be manipulated is the mortality rate while others remain constant. The mortality is assumed to decrease by 2% and 4%.
- Scenario 3: The variable that will be manipulated is the interest rate while the others remain constant. The interest rate is manipulated with two set-ups, which are low interest rate at 4% and high interest rate at 8%.
- Scenario 4: The variable that will be manipulated is the salary growth rate while others remain constant. The salary growth rate is assumed to be at a low rate of 3% and high rate of 8%.
- Scenario 5: A combination of two variables (retirement age and mortality rate) will be manipulated while the others remain constant. Retirement age is assumed to be 58, 60 and 62 years old and mortality rate is assumed to decrease by 2% and 4%.
- Scenario 6: Combinations of retirement age with economic assumption (interest rate and salary growth rate) are manipulated, while the mortality rates remain constant. Retirement age is assumed to be 58, 60 and 62 years old, interest rate is assumed to be at a low rate of

4% and high rate of 8%, and salary growth rate is assumed to be at a low rate of 3% and high rate of 8%.

The changes of actuarial assumptions in Total Actuarial Liabilities (TAL) for each scenarios are estimated as follows:

$$Percentage\_changes = \left(\frac{TAL_i - TAL_{baseline}}{TAL_{baseline}} \right) \times 100 \quad (4)$$

where, $TAL_{baseline}$ is Total Actuarial Liabilities for baseline scenario and TAL_i is Total Actuarial Liabilities for scenario i where i = 1, 2, 3, 4, …, 6.

3. Results and Discussion

Scenario 1

The estimated percentage decrement in total actuarial liabilities for both male and female compared to the baseline scenario is presented in Table 1.

Table 1: Estimated percentage decrement in total actuarial liabilities for Scenario 1

Male			**Female**		
58	60	62	58	60	62
4.51%	9.48%	14.90%	2.00%	4.40%	7.23%

According to Table 1, it was found that the percentage decrement in total actuarial liabilities for male employees at age of retirement 58, 60 and 62 years old are 4.51%, 9.48% and 14.80% respectively. Meanwhile, for the female employees, the total actuarial liabilities were reduced by 2%, 4.4% and 7.23% respectively. This happens as when the age of the participant is increasing, the time to pay dues to the participant will be reduced. So, by increasing the retirement age, it will decrease the pension liability of a participant.

Scenario 2

The estimated percentage increment in total actuarial liabilities for both male and female compared to the baseline scenario is presented in Table 2. From Table 2, when the mortality rate is decreased by 2% with other manipulations being constant, the total actuarial liability increased by 0.69% and 0.35% for male and female respectively. However, by decreasing the mortality rate further by 4%, it raises the total actuarial liabilities by 1.38% and 0.7% for male and female respectively.

Table 2: Estimated percentage increment in total actuarial liabilities for Scenario 2

Male		**Female**	
Reduced 2%	Reduced 4%	Reduced 2%	Reduced 4%
0.69%	1.38%	0.35%	0.70%

In addition, when comparing between male and female employees, the study found that the percentage increment in total actuarial liabilities for male employees is two times larger than

female employees. This indicates that the effect is more significant among males compared to females as males recorded a higher percentage increment in total actuarial liabilities for all categories. The study also found that by adjusting the mortality rate, the percentage of total actuarial liability increase, indicating that when the mortality rate is reduced (fewer people die), the pension liability will increase. This happens as when people are likely to live longer, it will cost the government a larger amount of pension to be paid to the pensioners.

Scenario 3

The estimated percentage difference in total actuarial liabilities for both male and female compared to the baseline scenario is presented in Table 3.

Table 3: Estimated percentage difference in total actuarial liabilities for Scenario 3

Male		**Female**	
4%	8%	4%	8%
31.02%	-51.07%	32.43%	-53.89%

From Table 3, the estimated percentage differences in total actuarial liabilities for both male and female are increasing when the interest rate is at a low rate of 4%. However, by increasing the interest rate to a higher rate of 8%, the estimated percentage difference in total actuarial liabilities for both male and female decreases compared to the baseline.

Scenario 4

The estimated percentage difference in total actuarial liabilities for both male and female compared to the baseline scenario is presented in Table 4.

Table 4: Estimated percentage difference in total actuarial liabilities for Scenario 4

Male		**Female**	
3%	8%	3%	8%
-36.43%	36.09%	-36.85%	36.05%

From Table 4, the estimated percentage difference in total actuarial liabilities for both male and female decreases when the salary growth is at a low rate of 3%. However, by increasing the salary growth to a higher rate of 8%, the estimated percentage difference in total actuarial liabilities for both male and female increases compared to the baseline.

Scenario 5

The estimated percentage decrement in total actuarial liabilities for both male and female compared to the baseline scenario is presented in Table 5. From Table 5, when mortality rate for male employees is decreased by 2%, the estimated percentage decrement in total actuarial liabilities at retirement age of 58, 60 and 62 are 3.78%, 8.71% and 14.08% respectively. Meanwhile, when the mortality rate for male employees is reduced by 4%, the estimated percentage decrement in total actuarial liabilities at retirement age of 58, 60 and 62 are at an average of 3.05% 7.92% and 13.25% accordingly.

Table 5: Estimated percentage decrement in total actuarial liabilities for Scenario 5

	Male		**Female**	
Retirement age	Reduced 2%	Reduced 4%	Reduced 2%	Reduced 4%
58	3.78%	3.05%	1.61%	1.22%
60	8.71%	7.92%	3.98%	3.55%
62	14.08%	13.25%	6.78%	6.31%

In addition, when the mortality rate for female employees is decreased by 2%, the estimated percentage decrement in total actuarial liabilities at retirement age of 58, 60 and 62 are lower with an average of 1.61%, 3.98% and 6.78% respectively. Meanwhile, when the mortality rate for female employees is reduced by 4%, the estimated percentage decrement in total actuarial liabilities at retirement age of 58, 60 and 62 are 1.22%, 3.55% and 6.31% respectively. It was discovered that there is a significantly higher percentage decrement in male employees compared to female employees when the retirement age is increased gradually. The result found that the estimated percentage decrement in total actuarial liabilities would be increased after the adjustment of the retirement age. This indicates that it is important to consider the necessary actions onto the retirement age policy to guarantee the financial sustainability of the public retirement fund as the mortality rate is assumed to constantly be decreasing in the future.

Scenario 6

The estimated percentage difference in total actuarial liabilities for both male and female compared to the baseline scenario is presented in Figure 1.

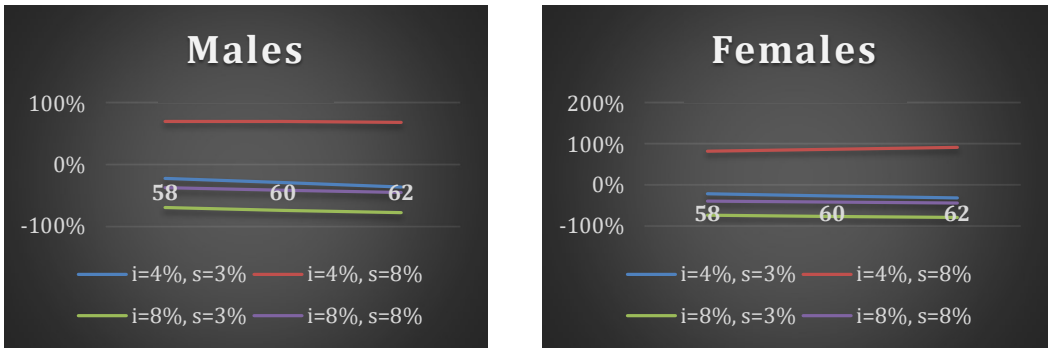

Figure 1**:** Estimated percentage difference in total actuarial liabilities for Scenario 6

As displayed in Figure 1, for male employees, when the retirement age is raised to 58, 60 and 62, the estimated percentage difference in total actuarial liabilities show a small falling trend in all situations whether when the interest rate and salary growth are at high or low rate. Furthermore, when both the interest rate and salary growth are at a low rate with 4% and 3%

respectively, the decreasing trend is clearly presented. For female employees, when the retirement age is raised to 58, 60 and 62, the estimated percentage difference in total actuarial liabilities shows a similar trend with male employees except for the case where interest rate is low and salary growth rate is high. Under this case, when the retirement age is raised to 58, 60 and 62, the estimated percentage difference in total actuarial liabilities is slowly raised up.

4. Conclusion

The study analyses the changes in total actuarial liabilities for different scenarios when the actuarial assumptions are manipulated. It was found that the sensitivity analysis conducted on the increasing retirement age causes the total actuarial liabilities to decrease. Besides, the sensitivity analysis on the decreasing mortality rate causes the total actuarial liabilities to increase, which deteriorates the pension fund. This is due to the circumstance that when the mortality rate decreases, people are likely to live longer, which means that there will be an increasing number of pensioners in the future. Thus, this will raise the pension cost that needs to be borne by the government. Even so, increasing the retirement age as what has been done in many other countries can compensate this. In addition, in a low interest rate situation, the total actuarial liabilities seem to be increasing which lead to deterioration of the pension system. Vice versa in a high interest rate, the total actuarial liabilities decrease. Thus, causes the pension system to improve. Furthermore, the study found out that when the salary growth is low, the total actuarial liabilities would decrease. So, when the salary growth rate is lowered, it is shown that the pension system is getting better. Vice versa, when the salary growth is high, the total actuarial liabilities will increase and worsen the pension system. In conclusion, by considering these findings, it is necessary for the Malaysian government to take early action in order to sustain the Malaysian pension system due to the population ageing.

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