ASM Sci. J., Special Issue 6, 2019 for SKSM26, 151-156

# Impact of an Ageing Population on Pension Expenditure using Autoregressive Distributed Lag Model

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Many countries including Malaysia are facing a rapidly ageing population. According to Malaysian Healthy Ageing Society (MHAS), Malaysia is also inevitably moving towards ageing population as those aged 60 years and above have grown from 6.2% in 2000 and is expected to hit 13.6% by 2030. Due to the inevitable ageing problem, it shows that pension expenditure has been tripled in the past ten years and thus an ageing population will cause pension expenditures in national budget to rise. Therefore, this study aims to forecast the Malaysian ageing population and analyse the impact of ageing population on Malaysian pension expenditure. The study used the Cohort Component Method to forecast the trend of ageing population, while Autoregressive Distributed Lag Model to analyse the impact of ageing population on pension expenditure. The component of old age dependency ratio, life expectancy, fertility rate, gross saving, unemployment rate and gross domestic product are used as ageing variables against pension expenditure. The results showed that Malaysia is anticipated to experience ageing population in future and life expectancy is the most significant variable that affects pension expenditure.

**Keywords:** aging population; pension expenditure; cohort component method; autoregressive distributed lag model

## I. INTRODUCTION

Ageing is a good development because the lifespan of the elderly population increases. Indirectly, the increase of number of elderly populations influences the number of pensioners. This situation will lead to increase the pension expenditure as the number of pensioners increases. Several researchers had discussed and highlighted the major issue that related to the impact of ageing population on the nation specifically on the pension expenditure. Ageing population is characterized by a growing proportion of the retired to the active working population and it gives negative impact to the economy as mentioned by Ismail *et al.* (2015) and Brendan and Sek (2017).

Hollanders (2012) and Militaru (2012) stated that ageing leads to increase total pension expenditure relative to GDP and the number of retirees. In addition, ageing also seems to be positively associated with health care spending. Total retirement spending will automatically increase if more people are eligible for pension benefits. This means that the pension expenditure spending is positively and slightly associated with the old-age dependency ratio. Militaru (2012) analysed the interrelationship between population ageing and the public pension system in Romania. He found that the impact of ageing on public pension expenditure is predicted to increase about 16% in 2060. This means that ageing population will automatically increase the pension cost for elderly. Thus, he suggested that the impact ofageing population on pension system will eventually reduce by increasing the retirement age. Ciobanu (2014) also agreed

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that older population will increase the people reaching retirement age and slightly increase the expenditure of public pension.

The level of expenditures is measure using ratio of pension expenditure such as benefit ratio, old-age dependency ratio, ratio of pensioner, and employment ratio. Bongaarts (2004) used the ratio of pensioners to worker as a demographic indicator to support the elderly since it is more accurate. This ratio is directly related to the ratio of old-age dependency and ratio of pensioner. However, it is inversely related to the ratio of employment. He concluded that by encouraging higher fertility, permit more immigration, increase labor force participation, rises the age at retirement, and reduce public pension benefit will counteract population ageing. Also, Verbič and Spruk (2014) indicated that the increment in rate of fertility and effective age of retirement have reduced public pension expenditure. Their findings suggested that added population will affect the long-term sustainability of public pension expenditure as a percentage of GDP. On average, the share of public pensions in GDP will increase if one percentage point of old-age dependency ratio increase. However, in Malaysia the study on the relationship between ageing population and pension expenditure is limited. Therefore, this study will analyse the trends of ageing population in Malaysia and investigate the impact of ageing population on pension expenditure in Malaysia.

## II. METHOD

Forecasting future trends of ageing population is very important for actuaries and other researchers. To forecast the ageing population in future, the cohort component method will be used in this study. This method consists three components which are survive, birth and migration.

$$P_{t+n} = S_t^{t+n} + B_t^{t+n} + M_t^{t+n} \tag{1}$$

where;

$P_{t+n}$ is the population at the end of the period (at time $t+n$);

$S_t^{t+n}$ is the survived population number during the period ($t$ to $t+n$);

$B_t^{t+n}$ is the number of births that take place during the period ($t$ to $t+n$); and

$M_t^{t+n}$ is the number of net migrants during the period ($t$ to $t+n$).

To forecast the ageing population by 5-year age groups, the Heligman-Pollard model will be used (Ibrahim *et al.,* 2017*)* and after that indirectly identifying the future survival ratio. In addition, to analyse the impact of ageing population on Malaysian pension expenditure, the Autoregressive Distributed Lag (ARDL) approach was developed by (Pesaran and Shin, 1999) and (Pesaran *et al.,* 2001) will be used in this study. Before the ARDL is applied, the unit root test needs to be conducted to ensure that all variables are stationary in level and difference form. The model used must also undergo diagnostic test to avoid the serial correlation and heteroskedasticity problem.

According to Cristian (2012), rate of fertility, life expectancy, and ratio of old age dependency are the proxies for ageing measurement. Ciobanu (2014) and Cristian (2012) applied additional variables to analyse the relationship between ageing population and pension expenditure which are gross saving, unemployment rate and gross domestic product to support their studies. However, in this study we only focus on old age dependency ratio (OADR), life expectancy (LE), total fertility rate (TFR), gross saving (GS), unemployment rate (UR) and gross domestic product (GDP). Therefore, the ARDL model for this study is given by:

$$\begin{aligned}\Delta \ln PE_t = {} & \beta_0 + \gamma_1 \sum_{i=0}^{p} \Delta \ln PE_{t-1} + \gamma_2 \sum_{i=0}^{p} \Delta \ln OADR_{t-1} \\ & + \gamma_3 \sum_{i=0}^{p} \Delta \ln LE_{t-1} + \gamma_4 \sum_{i=0}^{p} \Delta \ln TFR_{t-1} \\ & + \gamma_5 \sum_{i=0}^{p} \Delta \ln GS_{t-1} + \gamma_6 \sum_{i=0}^{p} \Delta \ln UR_{t-1} \\ & + \gamma_7 \sum_{i=0}^{p} \Delta \ln GDP_{t-1} + \lambda_1 \ln PE_{t-1} \\ & + \lambda_2 \ln OADR_{t-1} + \lambda_3 \ln LE_{t-1} \\ & + \lambda_4 \ln TFR_{t-1} + + \lambda_5 \ln GS_{t-1} \\ & + \lambda_6 \ln UR_{t-1} + \lambda_7 \ln GDP_{t-1} + \varepsilon_t\end{aligned} \tag{2}$$

where;

$PE_t$ is pension expenditure at time *t*;

$OADR_t$ is old-age dependency ratio at time*t*;

$LE_t$ is life expectancy at time *t*;

$TFR_t$ is total fertility rate at time *t*;

$GS_t$ is gross saving at time *t*;

$UR_t$ is unemployment rate at time *t*;

$GDP_t$ is gross domestic product per capita at time *t*;

$\beta_0$ is the drift component in the equation;

$\Delta$ represents change;

$p$ lag length;

$\gamma$ is the short run coefficient;

$\lambda$ represents the long-run (cointegration) relationship; and

$\varepsilon_t$ is error term.

## III. RESULTS AND DISCUSSION

### *A. Analysis of Future Trends of Ageing Population*

Figure 1 shows the forecasted male and female ageing population for year 2020, 2025 and 2030. According to this figure, it shows clearly that the number of this population increase significantly from year 2020 until 2030 for each age group of 60-64, 65-69, 70-74 and 75+. As a Malaysia ageing population increases, the number of working age population will decrease. Reduction in working age population will increase burden toward government since less people pay the taxes. This consequence caused the rate of taxes will increase to reduce the pressure bears by the government.

The indicator in judging a country that will experience ageing population is by evaluating the proportion of ageing population per total population.

In Malaysia, the proportion of aged population is only 5.53 percent in 1974 but has increased to 9.05 percent in 2015. Table 1 shows the forecasted percentage of ageing population per total population which include male and female. It is anticipated that male ageing population per total population in year 2020 is around 10.61 percent and 13.59 percent in 2030. Male ageing population keeps growing bigger where this population is expected to reach 9.88, 11.34, and 12.39 percent per total population in year 2020, 2025 and 2030 respectively. For female ageing population, the percentages are 11.40, 13.26 and 14.92 percent. This result is supported by Samad and Mansor (2013) where Malaysia is forecasted to become an aged population by 2030 when the ageing population will reach almost 15 percent of total population. In addition, according to United

Nations (2015), the report anticipated that Malaysia's ageing population will reach 14 percent out of total population.

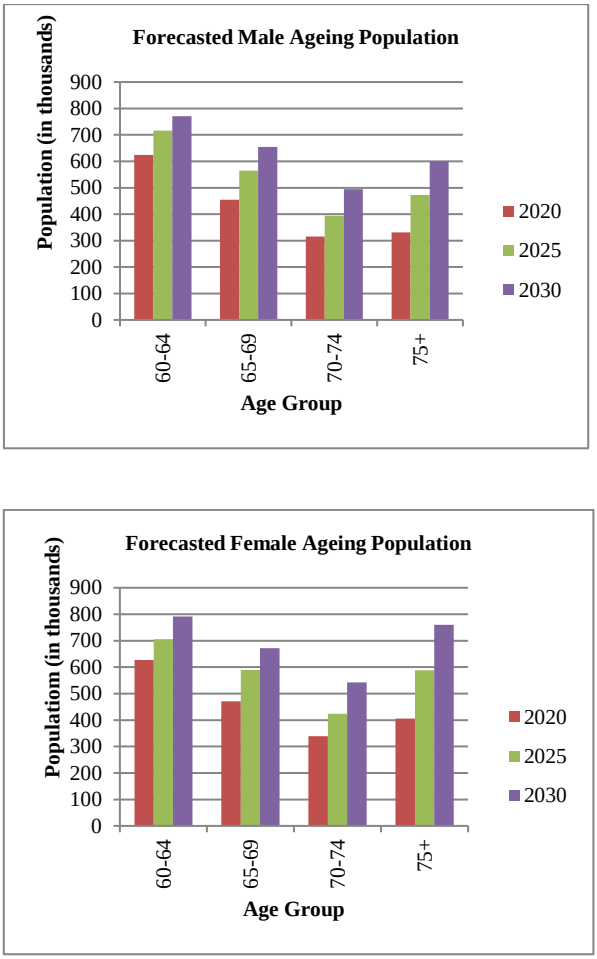


Figure 1. Forecasted Results of Male (top) and Female (bottom) Ageing Population for Year 2020, 2025 and 2030

Table 1. Forecasted of Ageing Population in Malaysia for Year 2020, 2025 and 2030 (cut-off age 60 years and over)

| Year | 2020 (%) | 2025 (%) | 2030 (%) |
|---|---|---|---|
| **Male** | 9.88 | 11.34 | 12.39 |
| **Female** | 11.40 | 13.26 | 14.92 |
| **Total** | 10.61 | 12.26 | 13.59 |

### *B. Analysis the impact of ageing population on Malaysian pension expenditure*

In this study, a unit root test was done for all variables using the Augmented Dickey Fuller (ADF) and Philip-Perron (PP). The importance of unit root test is to ensure that there is no spurious regression problem involve. The result of unit root tests is shown in Table 2.

Table 2. Result of Augmented Dickey Fuller and Philip-Perron test

| Variable | Unit Root Test (ADF) | Unit Root Test (PP) |
|---|---|---|
| PE | I(1) | I(1) |
| OADR | I(1) | I(1) |
| LE | I(0) | I(0) |
| TFR | I(1) | I(0) |
| GS | I(1) | I(1) |
| UR | I(1) | I(1) |
| GDP | I(1) | I(1) |

According to Table 2, it shows that the Augmented Dickey Fuller test result presents that all the variables are I(1) except for life expectancy and the PP test result shows that life expectancy and total fertility rate are stationary at level form and other variables are stationary at differenced form. Thus, it was concluded that both tests have a mixture of I(0) and I(1) variables.

In addition, to make sure that the model used do not involve in serial correlation and heteroskedasticity problem, the diagnostic tests need to be conducted. In the study, the Breusch-Godfrey Serial Correlation LM Test and Breusch-Pagan-Godfrey (heteroskedasticity test) are used as measurement to discover the serial correlation and heteroskedasticity problem. The results of Breusch-Godfrey Serial Correlation LM Test and Breusch-Pagan-Godfrey are 0.0315 and 0.6954 respectively. Thus, it was found that there are no serial correlation and heteroskedasticity problem in the model. Hence, we can proceed to examine the long-run relationship among variables by following null hypothesis:

$H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = \lambda_7 = 0$ (no long-run relationship) and alternate hypothesis

$H_1 : \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq \lambda_6 \neq \lambda_7 \neq 0$ (long-run relationship).

Table 3. Result of ARDL Bound Test

| Test Statistic | Value | Sig | I(0) | I(1) |
|---|---|---|---|---|
| ***F*-statistic** | 21.98 | 10% | 2.22 | 3.31 |
| ***k*** | 6 | 5% | 2.62 | 3.86 |
| | | 1% | 3.51 | 5.12 |

Notes: The presented bounds critical values are taken from Narayan (2005) and *k* is the number of control variables

If the *F*-statistic value is higher than any critical values, the null hypothesis will be rejected. Based on result in Table 3, it was found that the *F*-statistic of ARDL Bound Test result is 21.98. Since this value is higher than any critical values of Narayan (2005), the null hypothesis will be rejected. Thus, this indicate that there is long-run relationship among PE, OADR, LE, TFR, GS, UR and GDP as shown in Table 4.

Table 4. Estimation of long-run coefficient value for Pension Expenditure

| Variable | Coefficient | *t*-Statistic | Prob. |
|---|---|---|---|
| **OADR** | 1.10 | 5.05 | 0.0001* |
| **LE** | 14.66 | 8.83 | 0.0000* |
| **TFR** | -0.01 | -0.06 | 0.9542 |
| **GS** | -0.31 | -4.33 | 0.0004* |
| **UR** | -0.01 | -0.36 | 0.7211 |

| | | | |
|---|---|---|---|
| **GDP** | -0.34 | -3.84 | 0.0011* |

Note: The symbol *shows significance at 1%

According to Table 4, it was found that OADR, LE, GS and GDP are statistically significant at 1% level. Based on the result, one percent increase in the OADR and LE are estimated to increase the pension expenditure by 1.10% and 14.66% respectively. These finding indicates that an increase of OADR will increase the pension expenditure due to the declining of working age population. And the improvement of life expectancy will increase naturally the number of pensioners who reaches the retirement age. Therefore, the longer life expectancy of Malaysia population, the higher expenditure endures by the government. Besides that, the finding indicates that the GS is considered giving an effect even though in one percent of gross saving will only affect 0.311% of pension expenditure. Similar with GDP, it will increase about 0.339% of pension expenditure, if it decreases of one percent.

In addition, it was found that as the fertility rate decrease by one percent, the pension expenditure is estimated to increase by 0.01%. This indicates that in long run, decrease in fertility rates will increase in ageing and cause an increase in pension expenditure. Also, if the unemployment rate increase by one percent, the pension expenditure is predicted to decrease by about 0.01%. This is because when the unemployment rate decline, the number of employees will increase. If the number of elderly employees increases and they choose to retire early, this may bring to increase in pension expenditure.

## IV. SUMMARY

In conclusion, the ageing population issue has been becoming a big issue due to substantial number of older populations has been increase over the year and this situation will lead to increase the pension expenditure. This study carried out an investigation on trend of ageing population in future and an overview to the Government on impact of ageing population on Malaysian pension expenditure. The Cohort Component Method was used to forecast the trend of ageing population, while Autoregressive Distributed Lag Model was used to analyse the impact of ageing population on pension expenditure. The component such as ratio of old age dependency, life expectancy, rate of fertility, gross saving, rate of unemployment and gross domestic product are used as ageing variables against pension expenditure. The results indicated that ratio of old-age dependency and life expectancy have a significant effect on the pension expenditure in the long run. However, the results showed that life expectancy is the most significant variable that affects pension expenditure. From the positive perception, the ageing is a good development because it will increase the life expectancy, but it gives pressure toward the government budget since the allocation for elderly need to increase significantly. The older population will fall into poverty level if no action taken by the responsible party. Forward planning is essential for future economic growth in encountering ageing problem. In Malaysia, the effective retirement age for public sector employees has increased to 60 years old. This is one of the ways to reduce government's burden and help the retirees from insufficient financial income. In addition, this study also gives advantage to the insurance company to set appropriate premium for the older people due to changes in life expectancy. Hence, the Government and insurance company will aware about this issue and take appropriate action to combat this issue as well as protecting our economy growth.

## V. ACKNOWLEDGEMENT

The authors are grateful to the Department of Statistics, Malaysia and Public Service Department of Malaysia (Pension Division) for providing the data and MOE USIM/FRGS/FST/32/50615 for the financial support.

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