Comparison of Pension Fund Calculations Using Actuarial Methods of *Projected Unit Credit* and *Pay-As-You-Go*

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Abstract

Pension fund is an alternative option in providing old-age insurance for employees who do not work anymore due to the expired working age limit, by way of planning periodic payments called pension benefits. One of the factors affecting the pension fund is the amount of basic salary of the last month and years of service. This study discusses the computation of pension fund using projected unit credit and pay-as-you-go method on the data of Insurance Company "ABC". The method used herein is to calculate the retirement benefits earned by participants after entering the retirement age, and the amount of the normal contribution to be paid by the participants of the pension plan and the actuarial liability to be paid by the company. The results show that the calculation of pension benefits and normal contributions using the projected unit credit method is more profitable for the employees because of the same fee as the pay-as-you-go method, but the pension benefits received by the retired participants are greater.

Keywords:
Pension funds, retirement benefits, normal contributions, actuarial liabilities, projected unit credit, pay-as-you-go.

1. Introduction
Uncertainty of human life no one can predict it. For example, uncertainty will occur in the future. For a civil servant, productive age will support the welfare of his life, including home, car, health, and all the needs with salary earned. However, the welfare may be disrupted if the employee is sick, the accident causing the defect to the possibility of death, or unproductive again due to age (Haberman and Owadally, 2001; Owadally, 2003). Because of these risks, the need for welfare insurance to reduce the risk that will occur, one of which is the guarantee for old age (Lenze, 2009). The old-age insurance program is intended to ensure and provide protection for employees who will retire in their old age (Gerke et al., 2006).

The risk of old age causes the inability to earn an income and leads to economic difficulties for both themselves and families / dependents. But this risk can be avoided or reduced by participating in the pension plan (Devolder and de Valeriola, 2017; Sukono et al., 2016). A pension plan is a remuneration program provided by employers / employers to improve the welfare of their employees in old age (Ramaswamy, 2012; Kompa and Witkowska, 2016). There are several methods of calculating pension funds. Among other methods are unit credit and pay-as-you-go (PAYG) method. Hendriksen (2017), Butt (2009), and Viorica et al. (2012), in his research

includes a discussion of the Projected Unit Credit Method and the Entry Age Normal Method, in the calculation of actuarial liability and normal contributions. Based on the discussion can be concluded that the amount of normal contribution using Projected Unit Credit method continues to increase along with the increase in salary received. The normal contribution using the Entry Age Normal method is the same for each year for an employee. Similarly, the normal contribution using the Projected Unit Credit method is higher, than using the Entry Age Normal method from the middle of the year of participation. The amount of actuarial liability using the Projected Unit Credit method is smaller than using the Entry Age Normal method for each employee in each year.

Based on research conducted by Godinez-Olivares et al. (2016), Kotamaki (2013), and Settergren & Mi Kula (2005), 'Pay As You Go' is defined as direct funding by the employer, and payments will be made simultaneously from the employee entering retirement. This system has its own advantages because the budgeting will be known by the employer clearly, and the amount for the salary of the pensioner is determined by the employer based on the amount of real calculation. While the weakness that the budget for pension payroll salaries will increase. As more and more employees will retire, if they continue to use the Pay As You Go system, the budgets that the employer must spend will be as large as the budget spent on paying an active employee's salary or even more.

In this paper the type of pension plan discussed, is defined benefit retirement plan using actuarial methods projected unit of credit and pay-as-you-go. The goal is to calculate the normal contributions and pension benefits earned by pension participants, and make a comparison between the two methods used.

2. Research Methodology
In the research method discussed several methods of calculation, used in the comparison of methods of calculation of pension funds. It starts with a discussion of calculations for normal retirement.

2.1 Normal Pension Calculation using Projected Unit Credit Method
The projected unit credit (PUC) method is to divide the total pension benefits at the normal retirement age by the total length of service into a unit of pension benefit unit which is then allocated to each year during the period of employment (Chen and Matkin, 2017).

According to Aitken (1994), the benefits of retirement of participants at age r based on PUC method formulated by equation:
$$B_r = k\, S_{r-1}(r - e) \tag{1}$$
Based on the last salary assumption $S_{r-1=}(1 + S)^{r-1-x}S_x$ so that:
$$B_r = k\,(1 + S)^{r-1-x}S_x(r - e) \tag{2}$$
While the benefits of retirement of participants at age x based on PUC method formulated by equation:
$$B_x = k\,(1 + S)^{r-1-x}S_x(x - e) \tag{3}$$
Using the projected unit credit method, the normal fee is formulated by the equation:
$$^{PUC}(NC)_x = k\,(1 + S)^{r-1-x}S_x\frac{D_r^{(T)}}{D_x^{(T)}}\ddot{a}_r^{(12)} \tag{4}$$

Where:
r : Normal retirement age
x : Age at the time of valuation
e : Entry age of the participants
k : The percentage of normal pension benefits
S : The proportion of salary increases

2.2 Normal Retirement Calculation with Pay-As-You-Go Method
According to Godinez-Olivares et al. (2016) actuarial balance in the pay-as-you-go system aims for transparency in the management of public finances, and a desire to provide a more credible system in the eyes of contributors and retirees. The actuarial balance also aims to measure the financial sustainability of the system with the time horizon of the year (75 years in the United States and Canada).

In the calculation of actuarial balance (AB), it measures the present value difference discounted by the projected outcome of the trust fund assets, that is between the pension expense and the income from the contribution, expressed as the percentage of present value of the contribution under a certain period of time, taking into account that the level of the financial reserves (trust funds) at the end of the period reaches a one-year expenditure. Revenues and expenses are discounted using the projected earnings of the financial assets in each period, so the financial

balance point in the valuation period is zero. In a simplified form, AB can be expressed as (Godinez-Olivares et al., 2016):

$$AB = \underbrace{\left[\frac{TF_0 + y_0 \sum_{t=0}^{74} \theta_t N_t \prod_{h=1}^{t} \frac{(1+g_h)}{(1+r_{h)}}}{y_0 \sum_{t=0}^{74} N_t \prod_{h=1}^{t} \frac{(1+g_h)}{(1+r_{h)}}}\right] - \left[\frac{B_0 \sum_{t=0}^{74} R_t \prod_{h=1}^{t} \frac{(1+\lambda_h)}{(1+r_h)} + \prod_{h=1}^{74} \frac{(TF_{74})}{(1+r_h)}}{y_0 \sum_{t=0}^{74} N_t \prod_{h=1}^{t} \frac{(1+g_h)}{(1+r_h)}}\right]}_{\approx\ 0} \tag{5}$$

or

$$AB = \underbrace{\frac{[TF_0 + y_0 \sum_{t=0}^{74} \theta_t N_t \prod_{h=1}^{t} \frac{(1+g_h)}{(1+r_{h)}}}{B_0 \sum_{t=0}^{74} R_t \prod_{h=1}^{t} \frac{(1+\lambda_h)}{(1+r_h)} + \prod_{h=1}^{74} \frac{(TF_{74})}{(1+r_h)}}}_{\approx\ 1} \tag{6}$$

with:

TF_0 : Trust Fund, asset value at the beginning of the valuation period
θ_t : The payroll tax rate during the year t
y_0 : Average contribution during the year 0
N_t : The number of contributors during the year t
g : Annual salary growth rate
r : The projected assets of trust funds
B_0 : Average pension benefit during the year 0
R_t : The number of pensions during the year t
λ : Benefit growth rate annually
TF_{74} : Asset value at the end of the evaluation period

From the actuarial equilibrium equation we get the normal fee equation based on PAYG method as follows:

$$A(NC)_x = y_0 \sum_{t=0}^{74} \theta_t N_t \prod_{h=1}^{t} \frac{(1+g_h)}{(1+r_{h)}} \tag{7}$$

While the benefits of retirement of participants at age r based on PAYG formulated as the equation:

$$B_r = B_0 \sum_{t=0}^{74} R_t \prod_{h=1}^{t} \frac{(1+\lambda_h)}{(1+r_h)} \tag{8}$$

2.3 Actuarial Liability for Retirement

Under the projected unit credit method, the normal retirement actuarial liability (AL) calculation, in which the employee's age x, and age at the start of work is e can be formulated as follows (Aitken, 1994; Kotamaki, 2013):

$$^r(AL)_x = k\,(1+S)^{r-1-x} S_x(x-e) \frac{D_r^{(T)}}{D_x^{(T)}} \ddot{a}_r^{(12)} \tag{9}$$

Whereas actuary obligations based on the pay-as-you-go method represent present value of benefits and present value of the target value of end target trust funds formulated by the following equation (Sattergren and Mi Kula, 2005):

$$^r(AL)_x = B_0 \sum_{t=0}^{74} R_t \prod_{h=1}^{t} \frac{(1+\lambda_h)}{(1+r_h)} + \prod_{h=1}^{74} \frac{(TF_{74})}{(1+r_h)} \tag{10}$$

3. Result and Analysis

In the section discussed the calculation of pension benefits and normal contributions using actuarial methods projected unit credit and pay-as-you-go.

3.1 Object Data

The data used in the calculation of pension funds, is secondary data from an insurance company "ABC" which organizes a pension plan. The data used include the age of the retired participant, the number of participants, the average length of service and the average monthly salary, as given in Table 1.

Table 1 shows the overall data used in calculating pension benefits. Based on the data can be seen the number of participants as much as 177 people and the average working period is determined based on the length of work an employee aged x at PT. Insurance "ABC". From the data, the retirement benefits obtained by participants after retirement, the amount of normal contribution to be paid by the participant pension, as well as the actuary obligations paid by the company.

Table 1. Data participants of PT. Insurance "ABC"

Ages	Number of participants	Average Working Period (Year)	Average Last Month Salary (IDR)
31	1	5	2,054,400
32	3	7	2,328,733
33	1	8	2,278,300
34	3	6.67	2,385,866
35	2	10	2,396,300
36	4	6.75	2,388,550
37	3	6.33	2,224,133
38	1	4	1,910,800
39	4	10	2,674,100
40	2	14	2,282,900
41	2	14	2,629,950
42	3	16.33	3,014,800
43	4	14.5	2,659,125
44	4	18	2,982,450
45	5	16.2	2,679,400
46	10	16.5	2,928,340
47	5	21.4	2,926,180
48	7	14.14	2,733,771
49	10	21.5	3,222,780
50	13	16.07	2,723,107
51	18	25.67	3,455,711
52	17	27.52	3,344,976
53	12	27.75	3,375,666
54	13	28.3	3,207,984
55	10	29.1	3,396,020
56	18	29.44	3,525,250

3.2 Projected Unit Credit Calculation

In this section, the calculation of pension benefits for a person aged $x = 35$, $x = 40$ and $x = 45$ years at the time of evaluation. It is assumed that a person is calculated to be a retirement participant by age $e = 25$ years and retire at age $r = 56$ year, the percentage of salary increase $S = 10\%$ and the percentage of normal pension benefit is $k = 2\%$. The calculation to obtain pension benefit for normal pension using Projected Unit Credit method is done by using formula (2), as follows:

$$B_{56} = 0.02 \cdot (1 + 0.1)^{56-1-35} \cdot (2,396,300) \cdot (56 - 25)$$
$$= 0.02 \cdot (1.1)^{20} \cdot (2,396,300) \cdot 31$$
$$= 0.02 \cdot 6.73 \cdot (2,396,300) \cdot 31$$
$$= 9,998,801.38$$

So the amount of retirement benefits earned by an aged person 35 year amount IDR $9,998,801.38$ per year. Subsequently calculated the normal contribution by using the formula (4), as follows:

$$^{PUC}(NC)_{35} = 0.02 \cdot (1 + 0.1)^{56-1-35} \cdot S_{35} \cdot \frac{D_{56}^{(T)}}{D_{35}^{(T)}} \cdot \ddot{a}_{56}^{(12)}$$

$$= 0.02 \cdot (1 + 0.1)^{56-1-35} \cdot S_{35} \cdot \frac{D_{56}^{(T)}}{D_{35}^{(T)}} \cdot \frac{N_{56}}{D_{56}}$$

$$= 0.02 \cdot (1.1)^{20} \cdot (2,396,300) \cdot \frac{185,808.43}{381,995.63} \frac{2,560,828.18}{185,808.43}$$

$$= 0.02 \cdot 6.73 \cdot (2,396,300) \cdot 6.7$$

$$= 2,161,031.27$$

So that the normal contribution for the 35-year-old pension participant is as amount IDR $2,161,031.27$ per year.

Then calculated the actuarial liability for the company based on equation (9).

$$^{r}(AL)_{35} = 0.02 \cdot (1 + 0.1)^{56-1-35} \cdot S_{35} \cdot (35 - 25) \frac{D_{56}^{(T)}}{D_{35}^{(T)}} \cdot \ddot{a}_{56}^{(12)}$$

$$= 0.02 \cdot (1 + 0.1)^{56-1-35} \cdot S_{35} \cdot (35 - 25) \frac{D_{56}^{(T)}}{D_{35}^{(T)}} \cdot \frac{N_{56}}{D_{56}}$$

$$= 0.02 \cdot (1.1)^{20} \cdot (2,396,300) \cdot (10) \frac{185,808.43}{381,995.63} \frac{2,560,828.18}{185,808.43}$$

$$= 0.02 \cdot 6.73 \cdot (2,396,300) \cdot (10) \cdot 6.7$$

$$= 21,610,312.66$$

So the actuarial obligations paid by the company amount to IDR $21,610,312.66$ per year.

3.3 Pay-As-You-Go calculations

Calculation for retirement benefits using the Pay-As-You-Go method $x = 35$ year based on equation (8):

$$B_{56} = B_{35} \cdot R_0 \cdot \frac{(1 + \lambda_1)}{(1 + r_1)}$$

with value B_{35} is:

$$B_{35} = 0.02 \cdot (1.1)^{20} \cdot (2,396,300) \cdot 10$$

$$= 3,225,419.8$$

So the magnitude B_{56} is:

$$B_{56} = 3,225,419.8 \cdot 1 \cdot \frac{(1 + 0,02)}{(1 + 0)}$$

$$= 3,225,419.8 \cdot (1,02)$$

$$= 3,289,928.2$$

So the retirement benefits earned by a 35 year old man is amount IDR $3,289,928.2$ per year

Furthermore, the calculated normal contribution paid by the retired participant by using equation (7):

$$(NC)_{35} = y_0 \cdot \theta_0 \cdot N_0 \cdot \frac{1 + g_1}{1 + r_1}$$

For value

$$y_0 = b_x v^{r-x} {}_{r-x}p_x \ddot{a}_r^{(12)}$$

$$= b_{35} v^{56-35} {}_{56-35}p_{35} \ddot{a}_{r56}^{(12)}$$

with

$$b_{35} = 0.02 \cdot (1.1)^{20} \cdot 2,396,300$$

$$= 322,541.98$$

So the value y_0 is:

$$y_0 = 322,541.98 \cdot \left(\frac{1}{1 + i}\right)^{21} \frac{l_{56}}{l_{35}} \frac{N_{56}}{D_{56}}$$

$$= 322,541.98 \cdot \left(\frac{1}{1 + 0,025}\right)^{21} \frac{740,631}{906,554} \frac{2,560,828.18}{185,808.43}$$

$$= 322,541.98 \cdot 0.53 \cdot 0.82 \cdot 13.78$$

$$= 1,931,635.54$$

So the value $(NC)_{35}$ is:

$$(NC)_{35} = 1,931,635.54 \cdot 1 \cdot \frac{(1 + 0.1)}{(1 + 0)}$$

$$= 2,124,799.09$$

So the normal fee to be paid by the participants is IDR $2,124,799.09$ per year.

Then calculated the actuarial liability paid by the company using equation (10), as follows:

$$^r(AL)_x = B_0 \cdot R_0 \cdot \frac{(1 + \lambda_1)}{(1 + r_1)} + \prod_{h=1}^{74} \frac{(TF_{74})}{(1 + r_h)}$$

$$^{56}(AL)_{35} = B_{35} \cdot 1 \cdot \frac{(1 + 0.02)}{(1 + 0)} + 0$$

$$= 3,225,419.8 \cdot (1.02)$$

$$= 3,289,928.2$$

So the actuarial obligations paid by the company amount to IDR $3,289,928.2$ per year.

3.4 Results of Data Analysis

From the data processing done, the results of the calculation carried out the analysis as follows. By using the projected unit credit method, the benefits of retirement at age 35, 40 and 45 years, respectively are IDR $9,998,801.38$, IDR $5,916,363.64$ and IDR $4,302,580.52$, and the normal contributions to be paid by the participants of the pension amount IDR $2,161,031.27$, IDR $1,484,816.42$ and IDR $1,265,791.43$, so that the actuarial liability amounts to IDR $21,610,312.66$, IDR $22,329,502.48$ and IDR $25,315,828.61$.

Meanwhile, by using the pay-as-you-go method, the retirement benefits on the age 35, 40 and 45 year is IDR $3,289,928.2$, IDR $2,920,011.73$ and IDR $2,831,375.57$. The normal contribution payable by the participants of the pension amounts to IDR $2,124,799.09$, IDR $1,478,781.35$ and IDR $1,317,834.78$, so that the actuarial liability amounts to IDR $3,289,928.2$, IDR $2,920,011.73$ and IDR $2,831,375.57$.

Table 2. Projected Unit Credit and Pay-As-You-Go method

Ages	Benefit	Normal Contributions	Actuarial Liability
PUC Method			
35	9,998,801.38	2,161,031.27	21,610,312.66
40	5,916,363.64	1,484,816.42	22,329,501.48
45	4,302,580.52	1,265,791.43	25,315,828.61

Ages	Benefit	Normal Contributions	Actuarial Liability
PAYG Method			
35	3,289,928.20	2,124,799.09	3,289,928.20
40	2,920,011.73	1,478,781.35	2,920,011.73
45	2,831,375.57	1,317,834.78	2,831,375.57

Under the defined benefit pension plan, the amount of actuarial liabilities arising from the calculation of the two methods leads to the accumulation of funds from scratch, which can be a solution in case of depreciation of funds in a company. So that retired participants do not have to worry about the benefits to be gained at retirement age.

On the calculation of actuarial liabilities; from both methods it is seen that the actuary obligations paid by companies with pay-as-you-go method are more constant, compared to the projected unit credit method so that it will benefit the pension participants because the retirement benefits are more stable.

To see a comparison of the three methods, pension benefits, normal contributions and actuarial liabilities can be seen in Figures 1, 2 and 3 as follows:
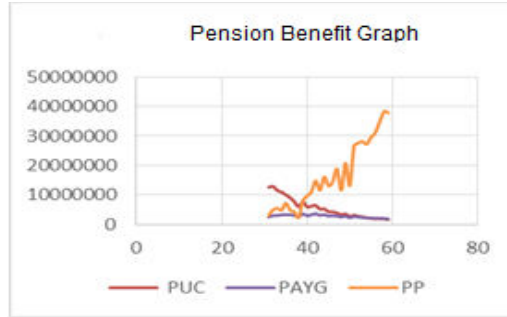
Figure 1. Pension Benefit Graph

Figure 1 describes the benefits of retirement at 31 years of age with the projected unit credit method larger than the age of 32 years, and so on so that the graph decreases. While the retirement benefits obtained by the pay-as-you-go method, are more constant at every age of evacuation. Furthermore, based on applicable government regulations, the pension benefit chart is more likely to increase due to an increase in pension benefits at any age.
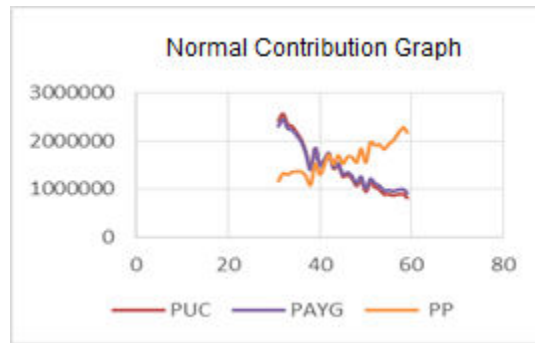

Figure 2. Normal Contribution Graph

Figure 2 explains the normal contribution paid by participants to the projected unit credit method tends to decline at any age, and is similar to the pay-as-you-go method. Furthermore, based on government regulations that apply the normal contribution paid by participants is much greater than the projected unit credit method and pay-as-you-go.
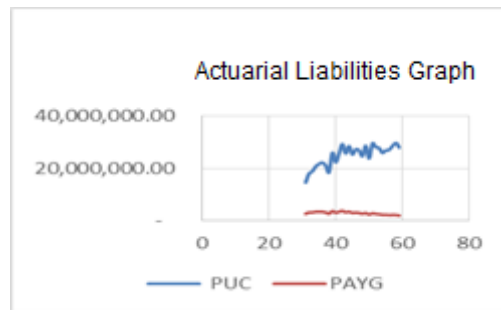

Figure 3. Actuarial Liabilities Graph

Figure 3 illustrates the actuarial liabilities paid by firms using the projected unit credit method much larger than the pay-as-you-go method. At 31 years of age, actuarial liabilities on the projected unit credit method increased during the later evaluation period. While actuary liabilities on the pay-as-you-go method, are relatively more constant at every age.

4. Conclusion

In this paper has been discussed about comparing the calculation of pension funds using the projected unit credit and pay-as-you-go method on the data of the Insurance Company "ABC". Based on the calculation of the data used, it can be put forward some conclusions as follows. The calculation of pension funds in this study uses the assumption of the last salary with the rate of increase in salary 10% and interest rates of $2\frac{1}{2}$%. In addition, it is assumed that a person is calculated to be a retirement participant at the age $e = 25$ years and retire at age $r = 56$ year. Based on the graph in Figure 1, the amount of retirement benefits obtained using the projected unit credit method is greater than the pay-as-you-go method. Based on the graph in Figure 2, the amount of normal dues to be paid by the participants using the projected unit credit method is similar to the pay-as-you-go. Based on the graph in Figure 3, the amount actuarial liabilities to be paid by the company using the projected unit credit is much larger than the pay-as-you-go method. The projected unit credit method is more profitable for the employee than the pay-as-you-go method, since the pension benefits received are greater, even though the normal contributions paid by pension participants are almost the same.

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