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Use of Constant Type Cost Prorate Method in Calculation of Actuarial Liability of Pension Funds

Veronica Clasrissa Putrie[1*], Himda Anataya Nurdyah[2]

[1,2] *Undergraduate Program in Mathematics, Faculty of Mathematics and Natural Science, Padjadjaran University, Sumedang, Indonesia*

Corresponding author email: veronica21004@mail.unpad.ac.id.

Abstract

The purpose of this study is to calculate the actuarial liability value of pension funds using the Constant Percent type Cost Prorate method. This method is a pension funding method that calculates pension benefits based on the employee's salary since he first entered work. The method in this study is used to calculate the amount of actuarial liabilities that must be issued by the company to employees at the time of normal retirement, namely 58 years. The data used is the data of a Civil Servant of the Social Service in DKI Jakarta who is 55 years old. Normal contributions and actuarial liabilities that must be prepared by pension companies for pension plan participants increase as the age of pension plan participants increases. Based on the calculation results, the accumulated actuarial liabilities that must be prepared by the pension plan company in 2020 are IDR 3,843,981,410.

Keywords: Pension fund, *constant percent*, actuarial liability.

1. Introduction

Retirement, as a transition from an active career to a more relaxed phase of adulthood, is an important moment in one's life. To ensure financial well-being in retirement, pension funds are crucial (Brüggen, 2017). A pension fund is a pool of assets set up by a company or individual to provide a regular income or cash payment to retiring employees. The aim is to provide a stable source of income for retiring employees to maintain their desired standard of living after retirement (Pang, 2014).

In managing pension funds, companies are often faced with complex challenges related to the calculation of the value of actuarial liabilities (O'Brien, 2020). Unexpected pension expenditures, fluctuations in annual contributions, and other financial risks can become a significant burden for companies and affect the financial well-being of retiring employees. Therefore, it is important to choose the right calculation method to balance the long-term financial needs of the pension fund with the financial stability of the company (Cumming, 2024).

One method that is often used in calculating the actuarial liability value of pension funds is the Constant Type Cost Prorate Method (Caicedo, 2023). This method allocates pension expenditures evenly over the employee's working life, thereby minimizing fluctuations in annual contributions required by the company. In the context of civil servants in the DKI Jakarta Social Service, the application of the Constant Type Cost Prorate Method is crucial to maintain financial stability while ensuring financial well-being for retiring employees.

The purpose of this journal is to investigate the use of the Constant Type Cost Prorate Method in the calculation of the actuarial liability value of pension funds, focusing on a case study of a civil servant in the DKI Jakarta Social Service. An in-depth analysis will be conducted to understand the advantages, challenges, and practical implications of using this method in this context. Empirical data and appropriate methodologies will be used to provide a comprehensive insight into how the Constant Type Cost Prorate Method can be effectively used in pension fund management.

Through a better understanding of the application of the Constant Type Cost Prorate Method, it is hoped that this journal can make a valuable contribution to practitioners, researchers and decision makers interested in pension fund management and related financial risk management.

2. Literature Review

2.1. Pension Fund

Based on Law Number 11 of 1992, a pension fund is a legal entity that manages and runs a program with the promise of pension benefits. The funds are obtained from the fixed contribution of each participant plus the company's income allowance, and the participants have the right to get a share of the benefits after retirement.

2.2. Retirement Program

Based on Law No. 11 of 1992, it is explained that the Pension Program is any program that seeks retirement benefits for participants. There are two types of pension programs, namely the Defined Benefit Pension Program (PPMP) and the Defined Contribution Pension Program (PPIP). Defined Benefit Pension Program (PPMP) is a pension program whose benefits are stipulated in the Pension Fund regulations or other pension programs that are not a Defined Contribution Pension Program. While the Defined Contribution Pension Program (PPIP) is a pension program whose contributions are stipulated in the Pension Fund regulations and all contributions and development results are recorded in each participant's account as pension benefits.

2.3. Basic Actuarial Functions

Actuarial Basic Functions Actuarial basic functions are fundamental functions used to support the actuarial calculation process. The basic actuarial functions used in the formulation of pension determination include the survival function npx, interest rate function $v\ n$, salary function sx and benefit function Bx (Voutilainen, 2022).

2.3.1 Survival Function

The survival function npx is a function that shows the chance of an employee still working during the active working period until the specified time to retire which is defined as follows:

$$ {}_np_x = \frac{l_{x+n}}{l_x} \tag{1} $$

with,

l_x : Number of individuals alive at age x

2.3.2 Interest Rate

Interest rate vn is used to discount future payments to the current time, which is defined as follows:

$$ v^n = \frac{1}{(1+i)^n} \tag{2} $$

with,

v : Discount factor.

i : Interest rate per period.

: Number of periods.

2.3.3 Salary Function

Salary is a form of periodic payment made by employers to their employees as stated in the employment contract (Birnbaum, 2023). The salary received by an employee during their working life plays an important role in determining the amount of retirement benefits to be received. The salary function is usually formulated by taking into account annual growth.

$$ s_x = s_y \times \frac{(SS)_x}{(SS)_y} \times (a+P)^{x-y} \tag{3} $$

with,

s_x : Discount factor.

$\frac{(SS)_x}{(SS)_y}$: The ratio of the value at age x to the value at age y.

n : The growth factor from age x to age y, with a as the fixed factor and P as the growth variable.

2.3.4 Benefit Function

The benefit function is used to determine the amount of benefits paid to participants upon retirement, accelerated retirement, disability, or death (Su, 2020). There are three types of benefit functions used to obtain cumulative benefits, namely flat dollar unit benefit, career average, and final average. In this study, the benefit function used for normal retirement age is career average with the following formula:

$$ B_r = kS_r \tag{4} $$

with,

k : Benefit multiplier (often expressed as a percentage of final salary per year of employment)

S_r : Salary at retirement age r

2.3.5 Annuity Function

An annuity is a payment made by the Pension Fund to participants in a certain amount, which is made at certain intervals or periods of time, on an ongoing basis. Annuities can be obtained using the following formula:

$$\ddot{a_x} = \sum_{t=0}^{\infty} {}_tp_x^m v^t \quad (5)$$

with,

v^t : Discount factor for period k.

${}_tp_x$: The probability that a person of age x will live to the age of $x + t$

2.4. *Constant Percent Cost Prorate Method*

The Cost Prorate method is a method that shows pension benefits based on the employee's length of service and salary. It calculates the present value of future benefits based on a participant's cumulative salary from entry to retirement. This type can be used to calculate the amount of actuarial liabilities and normal contributions.

2.4.1 Actuarial Liability

Actuarial Liability is the obligation to provide pension benefits to pension plan participants who continue to work until the specified retirement age. The actuarial liability of the Constant Percent type can be written as follows.

$$^{CPPr}(AL)_y = \frac{^s\ddot{a}_{y:\overline{x-y}|}}{^s\ddot{a}_{y:\overline{r-y}|}} \times B_r \times {}_{r-x}p_x \times v^{r-x} \times \ddot{a}_r^{(12)} \quad (6)$$

with,

$^{CPPr}(AL)_y$: Actuarial liability using Constant Type Cost Prorate method at age y.

$\frac{^s\ddot{a}_{y:\overline{x-y}|}}{^s\ddot{a}_{y:\overline{r-y}|}}$: Present value of annuity paid from age *y* over the period $(x - y)$ divided by the value of present value of the annuity paid from age *y* over the period $(x - y)$

B_r : Pension benefits at retirement age r.

${}_{r-x}p_x$: The probability that a person aged x will survive to age r.

v^{r-x} : Discount factor for the period $(r - x)$

$\ddot{a}_r^{(12)}$: The present value of the annuity paid monthly at age r.

2.4.2 Normal Dues

Normal cost is an annual contribution paid in each year of active service with the contribution determined by one of several actuarial costing methods. Normal contributions are contributions that must be fulfilled or paid every year by participants during their active work period. In the Constant Percent type, the normal contribution is obtained from a percentage of the participant's salary.

$$^{CPr}(NC)_y = Ks_x \quad (7)$$

with,

$^{CPr}(NC)_y$: Normal dues at age *y*.

K : A factor or coefficient relating to retirement benefits.

s_x : The salary or income function at age x.

3. Material and Methods

3.1. Material

This research takes a case study for a Civil Servant of the DKI Jakarta Social Service who is a participant in the pension program in the year of entry into work, namely March 1992, male with an entry age of 25 years 9 months (x =25) and a current age of 55 years 5 months (x = 55) with a class when entering II-c and the current class Iv-c.

3.2. Methods

This research uses a quantitative approach with actuarial data analysis to evaluate the use of the Constant Type Cost Prorate Method in calculating the actuarial liability value of pension funds. The calculation process is carried out using the Microsoft Excel program to facilitate data processing and analysis. The following is an explanation of the stages carried out in this study:

1) Literature study and review of data to be used
2) Calculating PHDP Salary Function

3) Calculating the amount of retirement benefits
4) Calculating normal contribution
5) Calculating the amount of actuarial liabilities using the Cost Prorate Constant Percent method.

4. Results and Discussion

4.1 Actuarial Assumptions

The actuarial assumptions used in the calculation of pension funds for the sample in this study are as follows:

1. The salary function (PhDP) is calculated by projecting the current month's PhDP s_x to determine the PhDP in the first month of employment s_y, and subsequent months are calculated using the group allowance and the annual salary increase rate that has been set.
2. Retirement benefits are calculated based on the results of the PhDP calculation s_x multiplied by the proportion of salary k.
3. The proportion of salary k used to calculate retirement benefits is 2% of total salary during employment.
4. Each pension plan participant (employee) receives a normal pension without any other pension cases.
5. The mortality rate is based on the Indonesian Mortality Table IV (TMI IV) in 2019 with an actuarial interest rate
   (i) of 6%.
6. The method used to calculate pension funds is the *Constant Percent* type *Cost Prorate* method.

4.2 Pension Fund Calculation

The calculation of pension funds in this study includes the calculation of PhDP, the amount of pension benefits, normal contributions and actuarial liabilities using the Constant Percent type Cost Prorate method.

4.2.1 Basic Pension Income (PhDP)

The calculation of basic pension income (PhDP) in this study is based on the PhDP data of pension participants who were sampled in November 2020 using a predetermined group allowance of 3.056% per 4 years of participants getting a class increase as follows:

Table 1: Group Allowance of 3.056%

Groups	Group Allowance					
Id	1					
IIa	1.03056	1				
IIb	1.06112	1.03056	1			
IIc	1.09168	1.06112	1.03056	1		
IId	1.12224	1.09168	1.06112	1.03056	1	
IIIa	1.15280	1.12224	1.09168	1.06112	1.03056	1
IIIb	1.18336	1.15280	1.12224	1.09168	1.06112	1.03056
IIIc	1.21392	1.18336	1.15280	1.12224	1.09168	1.06112
IIId	1.24448	1.21392	1.18336	1.15280	1.12224	1.09168
IVa	1.27504	1.24448	1.21392	1.18336	1.15280	1.12224
IVb	1.30560	1.27504	1.24448	1.21392	1.18336	1.15280
IVc		1.30560	1.27504	1.24448	1.21392	1.18336
IVd			1.30560	1.27504	1.24448	1.21392
IVe				1.30560	1.27504	1.24448

Salary increase P The annual salary increase is 5.1% which is obtained from the average salary increase for civil servants for the last 5 years. Calculation of PhDP of participants from the first month of work until retirement who entered work at the age of 25 years 9 months (y = 25) and the current age of 55 years and 5 months (x = 55) using equation (3) with class allowances when entering work for class IIc listed in Table 1 and it is known that the amount of the current month PhDP is IDR 6,526,173 which will be used to determine the first month PhDP. sy.

$$s_x = s_y \times \frac{(SS)_x}{(SS)_y} \times (a + P)^{x-y}$$

$$s_y = \frac{s_x}{\frac{(SS)_x}{(SS)_y} \times (a+P)^{x-y}}$$

$$s_{25} = \frac{IDR\ 6{,}526{,}173}{\frac{1.21392}{1} \times (1+0.051)^{55-25}}$$

$$s_{25} = IDR\ 1{,}208{,}891$$

Based on the calculation with equation (3), the PhDP of participants during the first month of work is IDR 1,208,891 and the next PhPD is calculated in the same way using Microsoft Excel as follows:

Table 2: Group Allowance of 3.056%

Age	Groups	Salary Scale	s_x	S_x
25	IIc	1	IDR 1,208,891	IDR 1,208,891
25	IIc	1	IDR 1,208,891	IDR2,417,781
26	IIc	1	IDR 1,270,544	IDR 3,688,326
26	IIc	1	IDR 1,270,544	IDR 4,958,870
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
55	IVa	1.21392	IDR 6,526,173	IDR 1,093,576,114
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
57	IVc	1.24448	IDR 7,390,297	IDR 1,327,150,580
57	IVc	1.24448	IDR 7,390,297	IDR1,334,540,877
58	IVc	1.24448	IDR 7,767,202	IDR 1,342,308,078

4.2.2 Retirement Benefits

The amount of pension benefits of pension plan participants is obtained by multiplying the proportion of salary determined by k, which is 2% (k = 2%) with the amount of accumulated PhDP at retirement age 58 years $S58$ = IDR 1,342,308,078 using equation (2.4) is as follows:

$$\begin{aligned} B_r &= k \times S_r \\ B_{58} &= k \times S_{58} \\ &= 2\% \times IDR\ 1{,}342{,}308{,}078 \\ &= IDR\ 26{,}846{,}162 \end{aligned}$$

4.2.3 Normal Dues

The amount of normal contributions for pension plan participants with a retirement age of 58 years (r = 58) will be calculated using the Cost Prorate Constans Percent method as follows:

$${}^{CPr}(NC)_y = Ks_x$$

$${}^{CPr}(NC)_y = \frac{B_r \times {}_{r-y}p_y \times v^{r-y} \times \ddot{a}_r{}^{(12)}}{S_y{}^s\ddot{a}_{y:\overline{r-y|}}} \times s_x$$

$${}^{CPr}(NC)_y = \frac{B_r \times {}_{r-y}p_y \times v^{r-y} \times \ddot{a}_r{}^{(12)}}{S_y{}^s\ddot{a}_{y:\overline{r-y|}}} \times s_x$$

$${}^{CP58}(NC)_{25} = \frac{B_{58} \times {}_{58-25}p_{25} \times v^{-(58-25)} \times \ddot{a}_{58}{}^{(12)}}{S_{25}{}^s\ddot{a}_{25:\overline{58-25|}}} \times s_{55}$$

$${}^{CP58}(NC)_{25} = \frac{B_{58} \times \frac{l_{58}}{l_{33}} \times (1+0.06)^{-(33)} \times \ddot{a}_{58}{}^{(12)}}{S_{35} \times s_{25}(\frac{N_{25}-N_{58}}{D_{25}})} \times s_{55}$$

$$^{CP58}(NC)_{25} = \frac{B_{58} \times \frac{l_{58}}{l_{33}} \times (1+0.06)^{-(58-25)} \times \ddot{a}_{58}{}^{(12)}}{S_{25} \times s_{58}(\frac{N_{25}-N_{58}}{D_{25}})} \times s_{55}$$

$$^{CP58}(NC)_{25} = \frac{\text{IDR } 26{,}846{,}162 \times \frac{89295.83379}{98147.65072} \times (1+0.06)^{-(58-25)} \times 12.44759}{\text{IDR } 1{,}208{,}891 \times 1.02843(\frac{381202.01525-39253.66102}{22993.28445})} \times \text{IDR } 6{,}526{,}173$$

$$^{CP58}(NC)_{25} = \frac{\text{IDR } 26{,}846{,}162 \times 0.90981 \times (1.06)^{-(33)} \times 12.44759}{\text{IDR } 1{,}208{,}891 \times 1.02843(14.87166198)} \times \text{IDR } 6{,}526{,}173$$

$$^{CPr}(NC)_{25} = \text{IDR } 15{,}687{,}791$$

The normal contributions of pension plan participants from the beginning of employment to retirement using the *Cost Prorate Constant Percent* method can be determined using the same method with the help of *Microsoft Excel* as shown in Table 3 as follows:

Table 3: Normal Contributions from the First Month of Employment to Before Retirement

Age	Normal Dues
25	IDR 15,687,791
26	IDR 16,809,969
:	:
:	:
:	:
55	IDR 476,614,369
:	:
:	:
:	:
57	IDR 1,505,597,827

4.2.4 Actuarial Liability

At this stage, the amount of actuarial liabilities that need to be prepared by the pension fund company from pensionplan participants will be calculated using the *Cost Prorate Constant Percent* method.

$$^{CPPr}(AL)_y = \frac{^{s}\ddot{a}_{y:\overline{x-y|}}}{^{s}\ddot{a}_{y:\overline{r-y|}}} \times B_r \times {}_{r-x}p_x \times v^{r-x} \times \ddot{a}_r^{(12)}$$

$$^{CPPr}(AL)_y = \frac{\frac{s_y(N_y-N_x)}{D_y}}{\frac{s_y(N_y-N_r)}{D_y}} \times B_r \times \frac{l_r}{l_x} \times (1+i)^{-(r-x)} \times \ddot{a}_r^{(12)}$$

$$^{CPPr}(AL)_y = \frac{N_y-N_x}{N_y-N_r} \times B_r \times \frac{l_r}{l_x} \times (1+i)^{-(r-x)} \times \ddot{a}_r^{(12)}$$

$$^{CPP58}(AL)_{25} = \frac{N_{25}-N_{55}}{N_{25}-N_{58}} \times B_{58} \times \frac{l_{58}}{l_{55}} \times (1+0.06)^{-(58-55)} \times \ddot{a}_{58}^{(12)}$$

$$^{CPP58}(AL)_{25} = \frac{(381202.01525-49700.63757)}{(381202.01525-39253.66102)} \times \text{IDR } 26{,}846{,}162 \times \frac{89295.83379}{91597.38846} \times (1.06)^{-3} \times 12.44759$$

$$^{CPP58}(AL)_{25} = \frac{331501.37768}{341948.35423} \times \text{IDR } 26{,}846{,}162 \times 0.974873141 \times (1.06)^{-3} \times 12.44759$$

$$^{CPPr}(AL)_{25} = \text{IDR } 265{,}169{,}037$$

Based on this calculation, the actuarial liability of the current pension plan participants is IDR 265,169,037. The

actuarial liabilities of pension plan participants from the beginning of employment until retirement using the *Cost Prorate Constant Percent* method can be determined using the same method with the help of *Microsoft Excel* as shownin Table 3 as follows:

Table 4: Actuarial Liability from the Beginning of Employment to Retirement

Age	Actuarial Liability
25	-
26	IDR 3,152,316
27	IDR 6,495,704
28	IDR 10,042,148
29	IDR 13,804,327
30	IDR 17,795,720
31	IDR 22,030,663
32	IDR 26,524,664
33	IDR 31,294,047
34	IDR 36,356,178
35	IDR 41,729,537
36	IDR 47,434,741
37	IDR 53,493,555
38	IDR 59,929,956
39	IDR 66,769,239
40	IDR 74,040,834
41	IDR 81,775,432
42	IDR 90,006,347
43	IDR 98,770,749
44	IDR 108,108,212
45	IDR 118,064,154
46	IDR 128,687,316
47	IDR 140,032,541
48	IDR 152,158,809
49	IDR 165,129,255
50	IDR 179,012,936
51	IDR 193,889,347
52	IDR 209,840,096
53	IDR 226,963,385
54	IDR 245,368,473
55	IDR 265,169,037
56	IDR 286,490,264
57	IDR 309,451,410
58	IDR 334,170,018
Amount	**IDR 3,843,981,410**

4.3 Discussion

The results of this study indicate that the pension calculation carried out in November 2021 for a Civil Servant who is a participant in the pension program in the year of entry into work, March 1992, is male with an entry age of 25 years and 9 months (x = 25) and the current age is 55 years and 5 months (x = 55) with a class when entering IIc and the current class IVc, the accumulated PhDP at retirement age 58 years is obtained S58 = IDR 1,342,308 with a retirement benefit of IDR 26,846,162. In this method, the age when starting work and the amount of salary of the pension plan participants affect the amount of benefits and standard contributions. The higher the age at which the participant starts working, the greater the normal contributions and retirement benefits that will be received . The accumulated actuarial liability that must be prepared by the pension fund company is IDR 3,843,981,410.

5. Conclusion

From the results of the analysis using the *Cost Prorate Constant Percent* method on a Civil Servant who is a participant in the pension program in the year of entry into work, namely March 1992, male with an entry age of 25

years 9 months ($x = 25$) and the current age of 55 years and 5 months ($x = 55$) with a class when entering IIc and the current class Ivc can be concluded as follows:

a. Normal contributions, which are calculated using the *Cost Prorate Constant Percent* method, increase significantly each period as the age of pension plan participants increases.
b. The amount of actuarial liabilities that must be prepared by the pension fund company for pension plan participants from the beginning of employment until retirement, which is calculated using the *Cost Prorate Constant Percent* method, increases with the age of pension plan participants. Thus, the high and low actuarial liabilities that must be prepared by the pension fund company are highly dependent on the normal contributionspaid by the pension plan participants.
c. In this method, the starting age and salary of the pension plan participant affect the amount of benefits and standard contributions. The higher the participant's starting age, the higher the normal contributions and retirement benefits.
d. Based on the calculation results, the accumulated actuarial liability that must be prepared by the pension fund company is IDR 3,843,981,410.

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