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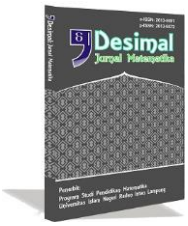

Financial mathematics of pension funds using entry age normal and projected unit credit methods

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ABSTRACT

ASN is an abbreviation for State Civil Apparatus. ASN is a term for professions that work under the auspices of government agencies at both the central and regional levels. This regulation of rights and obligations is a form of state intervention in the regulation of ASN. In implementing the AAUPB (general principles of good government) ASN Law, it was found that there were differences in the rights and obligations of PNS and PPPK. According to Article 21 of the ASN Law, civil servants have the right to receive salaries, allowances, holidays, old age security, protection, and increased qualifications. Meanwhile, according to Article 22, PPPK has the right to receive salary allowances, holidays, protection, and competency development. A very significant difference in the rights that PPPK does not receive is pension and old-age security. Based on this law, this research aims to provide a general overview of the pension calculations that will be received by PPPK using the EAN and PUC methods, so that of these two methods, which method is better for the number of normal contributions and actuarial obligations for participants and agencies between EAN and PU? Based on the calculation results, the method PUC (Project Unit Credit) is more suitable to use because there is no significant difference between normal contributions and actuarial obligations, so it can be profitable for both parties.

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INTRODUCTION

In this increasingly developing era, income is something that every adult must have because all important needs would not exist without the money we earn from our work. Therefore, all adults must look for ways to earn income, whether fixed or not, a lot or a little. The most important thing is that it can meet the most important needs. However, every employee who works in a company or community has a time limit or work period because they have reached retirement age

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and can no longer work actively (Tobing & Manullang, 2021).

Everyone needs income to support themselves and their families (Izzati & Kartikasari, 2022). These necessities of life remain even after retirement age. This means that everyone should plan to maintain a steady income level in retirement. One of the best ways to prepare for retirement is to join a retirement program. Post-retirement working life is still long and still requires quite high living costs, especially for those who have family responsibilities. When we are productive, working can meet our daily needs, but when we enter retirement or old age, we will not have enough income to meet our daily needs. A person needs to accumulate savings to meet his needs even when he no longer works, retires, or even dies. Old age can cause an inability to earn an income and an economic downturn for oneself and the family.

To overcome this risk, various efforts have been made to prevent it, including by participating in pension fund schemes. The aim of this program is to increase employee benefits so that employees and their families do not face financial difficulties when employees grow older, retire, or die. Pension programs commonly used by the government and private companies are classified into two types, namely defined benefit pension programs and defined contribution pension programs (Dian, Ashadi, & M, 2024). A defined-benefit pension program is a pension program whose pension benefits have been determined in advance in pension fund regulations. A defined contribution pension scheme is a pension scheme where payments or insurance contributions have been determined in advance in the pension fund regulations, and each payment and progress is recorded in the account of each participant in the form of pension benefits (Fridayanti, 2016).

The acronym for State Civil Apparatus is ASN. The term "ASN" refers to a group of professions that are employed by central and regional government organizations. Law number 5 of 2014 states that ASN is made up of Government Employees with Employment Agreements (PPPK) and Civil Servants (PNS) who are appointed by the Civil Servant Supervisory Authority and given general or civil service-related responsibilities, with salaries paid in accordance with statutory regulations.

ASN's rights and obligations are tied to PNS and PPPK. This regulation of rights and obligations is a form of state intervention in the regulation of ASN. In implementing the AAUPB ASN Law, it was found that there were differences in the rights and obligations of PNS and PPPK. According to Article 21 of the ASN Law, Civil Servants have the right to receive salaries, allowances, holidays, old age security, protection, and increased qualifications. Meanwhile, according to Article 22, PPPK has the right to receive salaries and allowances, holidays or leave, protection, and competency development. A significant difference between rights that PPPK does not obtain is old age security and old age security (Andriananda & Maulana, 2023).

According to earlier research by Delianti & Rohaeni (2022), published in the journal “Defined Benefit Pension Program Funding Calculation Model Using the Projected Unit Credit Method”, there is a 5% difference in the pension benefit values for participants who have the same basic salary and length of service. There is a 34% variance in basic salary between different working periods. Therefore, rather than service time, the quantity of basic pay has a greater impact on the financial value of pension benefits.

The research by Novika, Addini, & Kusdani (2023), entitled “Implementation of the Labor Laws in Indonesia for the Formulation of Pension Reserves”, is

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based on the Law of the Republic of Indonesia No. 6 of 2023 regarding job creation. The research findings highlight how the amended PUC method differs from the original method with regard to pension factors and pension benefit factors.

The research by Andani & Ramdani (2023), entitled "Evaluation of Projected Unit Credit and Attained Age Normal Techniques for Pension Funding", shows that the calculation is based on the present value of the pension benefit at the participant's retirement age. The research's findings demonstrate that the Projected Unit Credit method and the Attained Age Normal method for the normal contribution amount are greater than the Attained Age Normal method. The reduced fixed contribution paid by participants occurs the earlier they join the pension plan. The longer the work period is, the more actuarial liabilities there are for both approaches. When using the Attained Age Normal method instead of the Projected Credit Unit approach, the final value of normal contributions from the total normal contributions of each participant is higher.

Therefore, regarding the number of normal contributions and actuarial obligations for participants and agencies between EAN and PUC, this research tries to provide a general overview of the calculation of pensions that will be received by PPPK using the EAN and PUC methods.

METHOD

Funds are a collection of amounts of money in cash or non-cash, while retirement is when someone stops working because they have reached the maximum working age at their job (Abdullah & Wahjusaputri, 2018). A pension plan is a program that promises to pay a certain amount of money periodically after the participant stops working due to reaching retirement age (Nasir, 2016). In addition, a pension fund program is a form of future planning to ensure the retirement of workers (Daulay, Hidayana, & Halim, 2022). The method for paying pension funds must be systematic, namely explaining from the initial stage to the end of the work. This phase is continuous between departments according to their areas of responsibility (Arisca, Suhaidar, & Wenni Anggita, 2023).

State Civil Apparatus, also known as ASN, is one of the professional terms in Indonesia. ASN is a group of professionals who work in government agencies, both at the central and regional levels. All regulations regarding PNS, PPPK, or Government Employees to ASN are regulated in Law Number 5 of 2014 concerning State Civil Apparatus (Andriananda & Maulana, 2023). Actuarial assumptions are calculations of future changes applied to actuarial valuation. These changes, including changes in assumptions, can occur in each assessment period due to differences in assumptions and reality (Riaman, 2018).

A. Mortality Tables

Mortality tables are discrete probability distributions presented in the form of age-of-death probability tables. The formulation related to the mortality table is formulated by Novi et al. (2024).

$$d_x = E_x - E_{x+1} \quad (1)$$

B. Commutation Symbol

The commutation symbol is a symbol used to simplify the calculation of mortality tables for an annuity or series of payments (Miranda & Arnellis, 2022).

- Symbol D_x (Mahrani & Pangestu, 2023)

$$D_x = v^x E_x \quad (2)$$

- Symbol N_x (Aprijon, 2021)

$$N_x = \sum_{t=0}^{w-x} D_{x+i} \quad (3)$$

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C. Annuity

A lifetime annuity is a series of monthly and annual payments that are made continuously as long as the beneficiary is alive (Miranda & Arnellis, 2022). The following calculations are used in calculating pension funds:

- Initial Life Annuity (Rembet, Salsabila, Talarima, & Unwaru, 2023)

$$\ddot{a}_x = \frac{N_x}{D_x} \quad (4)$$

- Initial Term Annuity (Sulma, Widana, Toaha, & Fitria, 2023)

$$a_x = \frac{N_x - N_{x+n}}{D_x} \quad (5)$$

D. Basic Actuarial Functions

- Interest Rate Function

The interest function is used to discount future payments to the present (Julianty, Listiani, & Manurung, 2023)

$$v^x = \frac{1}{(1+i)^x} \quad (6)$$

- Benefit Function (Last Salary)

The benefit function is used to determine the amount of benefits paid at retirement age (Muchlian, Arsita, & Yuni, 2024).

$$B_r = k(r-e)S_{r-1} \quad (7)$$

- From pension benefits, the present value of pension benefits can be calculated. The magnitude is (Sukono et al., 2021)

$${}^{r}(PVFB)_x = B_r \ddot{a}_r v^{r-x}{}_{r-x}p_x \quad (8)$$

E. Normal Cost

Normal costs are payments made by participants to the pension fund according to the actuarial valuation method used. The following are several methods that can be used to calculate normal contributions (Syahrini, Nurmaulidar, Maulidi, & Alfira, 2020):

- Entry Age Normal Method

Formula (Syahrini et al., 2020)

$${}^{EAN\ r}(NC)_x = \frac{v^{x-e}\ {}_{x-e}p_e}{\frac{N_e - N_r}{D_e}}\ {}^{r}(PVFB)_x \quad (9)$$

- Project Unit Credit Method

Formula (Hutabalian, Widana, & Harini, 2021)

$${}^{PUC\ r}(NC)_x = \frac{{}^{r}(PVFB)_x}{r-e} \quad (10)$$

F. Actuarial Liabilities

Actuarial Liability (AL) is the value that a pension fund must have to fulfill its pension fund obligations to participants (Dian et al., 2024).

- Normal Age Entry Method (Dian et al., 2024)

$${}^{EAN\ r}(AL)_x = \frac{\frac{N_e - N_x}{D_e}}{\frac{N_e - N_r}{D_e}}\ {}^{r}(PVFB)_x \quad (11)$$

- Project Unit Credit Method (Putri S.R., Susanti, & Riaman, 2024)

$${}^{PUC\ r}(AL)_x = \frac{x-e}{r-e}\ {}^{r}(PVFB)_x \quad (12)$$

G. Final Value of Normal Contributions

The following formula will be used, namely (Andriananda & Maulana, 2023):

- Entry Age Normal Method

$${}^{\text{EAN r}}(\text{NA})_{\text{e}} = \sum_{\text{x=e}}^{\text{r-1}} {}^{\text{EAN}}(\text{NC})_{\text{x}}\ (1+\text{i})^{\text{r-x}} \quad (13)$$

- Projected Unit Credit Method

$${}^{\text{PUC r}}(\text{NA})_{\text{e}} = \sum_{\text{x=e}}^{\text{r-1}} {}^{\text{PUC}}(\text{NC})_{\text{x}}\ (1+\text{i})^{\text{r-x}} \quad (14)$$

The basic salary data used in this research is basic salary data on goals IX for PPPK based on PP (Presidential Regulation) Number 11 of 2024 (Peraturan Presiden RI, 2024), and PNS based on PP (Presidential Regulation) Number 10 of 2024 (Peraturan Pemerintah RI, 2024). Each salary data is taken from the period of service up to the age of the participants studied, who are 33 years old with a retirement age of 58 years, so they have only 25 years of service. Apart from that, this research uses the Indonesian Population Mortality Table

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(TMPI) 2023 for men and women (BPJS Kesehatan, 2023).

RESULTS AND DISCUSSION

A PPPK employee with goals IX, male, started to become a participant at the age of (e = 33 years), with a retirement age of (r = 58 years), so that his service period was (n = 25 years) and the basic salary received was IDR 3,203,600/month, the interest rate is (i= 6%) and the proportion of the pension benefit value is (k = 2.5%).

a. Calculate your salary each year

$S_n = s \times 12\ months$

$S_{33} = \text{IDR } 3{,}203{,}600 \times 12$

$= \text{IDR } 38{,}443{,}200$

The salary results for each year which will be shown in Table 1:

Table 1. The Annual Salary of PPPK Gol Participants IX Male

x	n	***Monthly salary***	S_x (***Annual salary***)
33	0	IDR 3,203,600	IDR 38,443,200
34	1	IDR 3,203,600	IDR 38,443,200
35	2	IDR 3,304,400	IDR 39,652,800
36	3	IDR 3,304,400	IDR 39,652,800
⋮	⋮	⋮	⋮
58	25	IDR 4,100,800	IDR 61,209,600

b. Calculating the amount of pension benefits (B_r)

$B_{58} = 2.5\%(58 - 33)S_{58-1}$

$B_{58} = 2.5\%(25)\text{IDR } 61{,}209{,}600$

$= \text{IDR } 38{,}256{,}000$

∴ So, the amount of pension benefits that participants will receive when they retire in a year is IDR 38,256,000

c. Calculating actuarial valuation

- Calculating values v^x

$v^0 = \frac{1}{(1+0.06)^0}$

$= 1$

- Calculating values D_x

$D_0 = v^0 \times E_0$

$= 1 \times 7{,}044{,}346.36$

$= 7{,}044{,}346.36$

- Calculating values N_x

$N_0 = D_0 + D_{0+1} + \ldots + D_{58}$

$= 167{,}317{,}760.8$

- Calculating values $\ddot{a}_x$

$\ddot{a}_0 = \frac{N_0}{D_0} = \frac{167{,}317{,}760.8}{7{,}044{,}346.36}$

$= 23.75206333$

Table 2 is the results of the actuarial assessment calculations:

Table 2. Calculation of Actuarial Valuation of Gol PPPK Participants IX Male

x	v^x	D_x	N_x	$\ddot{a}_x$
0	1	7,044,346.36	167,317,760.8	23.75206333
1	0.943396226	6,893,278.481	160,273,414.5	23.25068034
2	0.88999644	7,005,289.64	153,380,136	21.89490283
3	0.839619283	7,069,533.071	146,374,846.4	20.70502322
4	0.792093663	7,058,886.841	139,305,313.3	19.73474238
⋮	⋮	⋮	⋮	⋮
58	0.03406119	192.754,5553	192.754,5553	1

d. Calculate the present value of pension benefits (PVFB)

${}^{58}(PVFB)_{33} = B_{58}\ddot{a}_{58}v^{58-33}{}_{58-33}p_{33}$

${}^{58}(PVFB)_{33} = (\text{IDR } 38{,}256{,}000) \times (1) \times (0.232998631) \times \left(\frac{5{,}659{,}067}{9{,}897{,}710}\right)$

$= \text{IDR } 5{,}096{,}394$

Table 3 contains the present value of pension benefits(PVFB):

Table 3. The Present Value of the Pension Benefits (PVFB)of Gol PPPK Participants IX Male

x	${}_{r-x}p_x$	v^{r-x}	${}^{r}(PVFB)_x$
33	0.571755184	0.232998631	IDR 5,096,394
34	0.569757004	0.246978548	IDR 5,383,299
35	0.559899372	0.261797261	IDR 5,607,569
36	0.554912115	0.277505097	IDR 5,891,077
⋮	⋮	⋮	⋮
57	0.969152742	0.943396226	IDR 34,977,271

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e. Calculate the amount of normal contributions (NC)
   - Calculating Normal Contributions PUC

$$^{PUC}{}_{58}(NC)_{33} = \frac{^{58}(PVFB)_{33}}{58-33} = \frac{\text{IDR } 5{,}096{,}394}{25} = \text{IDR } 203{,}856$$

- Calculating Normal Contributions EAN

$$^{EAN}{}_{58}(NC)_{34} = \frac{v^1 \, {}_1p_{33}}{\frac{N_{33}-N_{58}}{D_{33}}} \, {}^{58}(PVFB)_{34}$$

$$= \frac{(0.943396226)(1.003507074)}{\frac{18{,}101{,}785.31-192{,}754{,}555.3}{1{,}446{,}908.844}} \times \text{IDR } 5{,}383{,}299$$

$$= \frac{0.9467047864}{12.3774423171} \times \text{IDR } 5{,}383{,}299$$

$$= \text{IDR } 411{,}749$$

f. Calculating the final value of normal contributions
   - Calculating the Final Value of Normal Contributions PUC

$$^{PUC\,r}(NA)_e = (\text{IDR } 203{,}856)(1+0.06)^{25} + (\text{IDR } 224{,}304)(1+0.06)^{24} + \cdots + (\text{IDR } 34{,}977{,}271)(1+0.06)^1$$

$$^{PUC}{}_{58}(NA)_{33} = \text{IDR } 874{,}923$$

   - Calculating the Final Value of Normal Contributions EAN

$$^{EAN\,r}(NA)_e = (Rp\ 411{,}749)(1+0.06)^{25} + (Rp\ 411{,}749)(1+0.06)^{24} + \cdots + (Rp\ 411{,}749)(1+0.06)^1$$

$$^{EAN}{}_{58}(NA)_{33} = Rp\ 1{,}767{,}172$$

Table 4 contains the results of the comparison of the Final Value of Normal Contributions between PUC and EAN.

Table 4. Results of Comparison of the Final Value of Normal Contributions between PUC with EAN PPPK Gol Participants IX Male

x	$^{PUC\,r}(NA)_e$	$^{EAN\,r}(NA)_e$
33	IDR 874,923	IDR 1,767,172
34	IDR 908,193	IDR 1,667,143
35	IDR 931,283	IDR 1,572,777
36	IDR 964,942	IDR 1,483,751
⋮	⋮	⋮
57	IDR 37,075,907	IDR 436,454

g. Calculating the amount of actuarial liabilities (AL)
   - Calculating Actuarial Liabilities PUC

$$^{PUC}{}_{58}(AL)_{33} = \frac{33-33}{58-33} \, {}^{58}(PVFB)_{33} = \frac{0}{25} \times \text{IDR } 5{,}096{,}394 = 0$$

   - Calculating Actuarial Liabilities EAN

$$^{EAN}{}_{58}(AL)_{33} = \frac{\frac{N_{33}-N_{33}}{D_{33}}}{\frac{N_{33}-N_{58}}{D_{33}}} \, {}^{58}(PVFB)_{33} = \frac{\frac{18{,}101{,}785.31-18{,}101{,}785.31}{1{,}446{,}908.844}}{\frac{18{,}101{,}785.31-192{,}754.5553}{1{,}446{,}908.844}} \times \text{IDR } 5{,}096{,}394 = \frac{0}{12.37744231} \times \text{IDR } 5{,}096{,}394 = 0$$

So that the comparison between normal contributions and actuarial obligations is obtained namely on Table 5.

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Table 5. Results of Comparison of Normal Contributions with Actuarial Liabilities between PUC with EAN PPPK Gol Participants IX Male

x	n	Normal Cost		Actuarial Liabilities	
		${}^{PUC\,r}(NC)_x$	${}^{EAN\,r}(NC)_x$	${}^{PUC\,r}(AL)_x$	${}^{EAN\,r}(AL)_x$
33	0	IDR203,856	IDR 411,749	IDR -	IDR -
34	1	IDR 224,304	IDR 411,749	IDR 215,332	IDR 434,928
35	2	IDR 243,807	IDR 411,749	IDR 448,606	IDR 881,950
36	3	IDR 267,776	IDR 411,749	IDR 706,929	IDR 1,359,105
⋮	⋮	⋮	⋮	⋮	⋮
57	24	IDR 34,977,271	IDR 411,749	IDR 33,578,180	IDR 34,565,522

Based on the Tables 5, it can be seen that the EAN (Entry Age Normal) method shows that the amount spent on contributions is always the same every year, but the actuarial obligations obtained actually increase each year even though the contributions paid remain the same. Meanwhile, the PUC (Project Unit Credit) method shows that the amount of normal contributions issued increases every year, as do the actuarial obligations obtained, but the difference is that at the beginning of the year and at the end of the year, there is a minus comparison between normal contributions and actuarial obligations where the normal contributions are more large compared to the actuarial obligations obtained, but this only applies at the beginning of the year, and at the end of the year, the remaining normal contributions will be smaller than the actuarial obligations obtained.

It can be concluded that the PUC method is more appropriate than the EAN method because in the EAN method, profits are more likely to go to employees but not to the agency, and the difference is visible, whereas in the PUC method, profits are more balanced and do not have prominent differences. So, the PUC method is more appropriate because it shows results that benefit employee participants but do not cause too much harm to the agency because the fees paid always increase every year, as do the actuarial obligations. What differentiates this research from previous research is that it lies in the data used; this research uses the latest mortality table, namely TMPI 2023, and the basic salary of employees used is PP number 11 of 2024. So this research is more recent from the point of view of the data used.

CONCLUSIONS AND SUGGESTIONS

Based on the discussion above, it can be concluded that the Normal Contribution using the PUC method increases every year, whereas with the EAN method, the Normal Contribution is always the same amount every year, even though both have different salaries every year. The actuarial obligations have similarities, namely that the nominal actuarial obligations obtained both increase every year, but the EAN method has a higher nominal value when compared to the PUC method. It can be concluded that the PUC method is more appropriate than the EAN method because in the EAN method, profits are more likely to go to employees but not to the agency, and the difference is visible, whereas in the PUC method, profits are more balanced and do not have prominent differences. So the PUC method is more appropriate because it shows results that benefit employee participants but do not cause too much harm to the agency because the fees paid always increase every year, as do the actuarial obligations.

The PUC method can be applied to pension calculations based on the results of the discussion above. This is due to the fact that neither employees nor agencies are usually impacted by the results of

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these calculations. In addition, it is hoped that later researchers will be able to refine this approach or compare it with alternative approaches so that the pension calculation process becomes more precise.

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