The Effect of Changes in the Indonesian Mortality Table on Pension Fund Calculations Using the Projected Unit Credit Method

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Abstract— Companies are required to prepare a pension fund for their employees as a form of appreciation and compensation for the services that have been given to the companies. In Indonesia, the calculation of pension funds is regulated in the Financial Services Authority Regulation (POJK) number 3 concerning Pension Fund Investments. This research aims to compare the impact of two different mortality tables [8][9] on pension fund results and analyze how changes in the Indonesian mortality table affect pension fund calculations. For this purpose, the researchers have chosen to apply the Projected Unit Credit (PUC) method for the pension fund calculations. Projected Unit Credit uses the distribution of pension benefits that pension participants will get if they work until they reach normal retirement age with a total of years of service. The data in this research uses salary data from PT. XYZ with the assumption of retirement age at the age of 58, and an interest rate of 6.25% based on Bank Indonesia's rate. Thus, the results of this research show that changes in normal cost and actuarial liability for both males and females are visible at the age of entry into employment until the middle of the working period, while the effect of changes in the mortality table at the final age approaching retirement is not very significant.

Keywords— Actuarial Liability; Mortality Table; Normal Cost; Pension Fund; Projected Unit Credit

I. INTRODUCTION

Companies must prepare a pension fund for their employees as a form of appreciation and compensation for the services given to the companies [1]. The calculation and provision of pension funds have their own provisions, methods, and regulations. In Indonesia, the calculation of pension funds is regulated in the Financial Services Authority Regulation (POJK) number 3 concerning Pension Fund Investments. According to POJK number 3, a pension fund is a legal entity that manages and runs a program that promises retirement benefits as referred to in the law regarding pension funds. Pension funds are divided into 2 types, namely the Employer Pension Fund (DPPK), which is a pension fund established by a company. In DPPK, the pension fund is required to have defined contributions for the benefit of all employees of a company who will be referred to as "participants". It will be an obligation to the company or employer. Furthermore, there is the Financial Institution Pension Fund (DPLK), which is a pension fund established by a bank or insurance company. In DPLK, pension fund contributions are prepared individually for both employees and self-employed workers who do not get DPPK [2].

Pension funds also have their own restrictions, such as being prohibited from being placed as investments, except in banks, government securities, shares listed on the stock exchange in Indonesia, mutual funds, and various other things listed in POJK number 3 article 2 [2]. In calculating pension funds, there are various important instruments that become indicators of calculation. These instruments are mortality tables, salary data, data when a person enters and leaves work, and others [3]. However, the above instruments, especially the mortality table, can change over time. In Indonesia alone, the mortality table has undergone several changes, starting from mortality table I (1993), mortality table II (1999), mortality table III (2011), mortality table IV (2019), and BPJS mortality table (2022). These changes can result from various factors, including shifts in mortality rates, life expectancy, disease patterns, and the effects of pandemics like COVID-19.

Furthermore, there are various methods to calculate pension funds such as Traditional Unit Credit (TUC), Projected Unit Credit (PUC), Entry Age Normal (EAN), Aggregate Cost Method, Attained Age Normal (AAN),

Individual Level Premium (ILP), and Terminal Funding. However, in this paper, we will only focus on the Projected Unit Credit method and compare the changes and effects of the mortality table changes in Indonesia.

II. LITERATURE REVIEW

A. Pension Fund

Pension funds are a right that was only obtained by civil servants before, but since the enactment of Law No. 11 of 1992 concerning Pension funds, pension funds have become a right that can be enjoyed by all employees. This pension fund can be interpreted as a fund that is specifically collected to later provide benefits to participants who have reached retirement age, disability, or death.

B. Mortality Table

1) Indonesian Mortality Table IV

Indonesian Mortality Table experienced evolution due to various factors such as changes in mortality rates, changes in life expectancy, changes in disease patterns, and the impact of pandemics such as COVID-19. Indonesian Mortality Table IV was published in 2019 after the last amendment took place in 2011 as a form of updating with current market conditions.

The differences between Indonesian Mortality Table III and IV are mortality Table IV uses a larger data exposure by involving 52 life insurance companies, which is an improvement from th preparation of TMI Year 2011 which was compiled using data from 40 companies, as well as adequate technology such as R software for data analysis and Phyton software for cleansing and validation processes. The mortality rate for men has an average improvement of around 5.33% compared to Indonesian Mortality Table III. Meanwhile, the mortality rate for women improved by 5.06%. Furthermore, the mortality rate for infants under 1 year has decreased when compared to the previous mortality table. This is in line with Indonesia's 2017 health profile where the infant mortality rate in 2017 has decreased when compared to the infant mortality rate in 2011.

2) BPJS Mortality Table

In 2023, the Social Security Administration (BPJS) for Health, in partnership with the Indonesian Actuary Association (PAI) and the Bandung Institute of Technology (ITB), produced a Mortality and Morbidity Table based on data from Indonesia's National Health Insurance System (JKN) members. The report also updates the mortality data, which was originally released in 2017 and 2010 under the name PT. Jamsostek (Persero).

BPJS Kesehatan's service data is a great resource for health analysis. These data provide detailed information on mortality and morbidity, including population mortality patterns, specific mortality rates, survival, life expectancy, health service utilization, disease prevalence and incidence, epidemiological transitions, and health system effectiveness, which is required when developing evidence-based health policies. This book contains mortality and morbidity tables based on data from practically the entire Indonesian population. This book provides important statistics, such as the Indonesian population's growing life expectancy of 73.74 years for men and 78.37 years for women.

C. Formula

A mortality table is primarily a list of the lives and deaths of a group of people.

1) $_np_x$ is defined as the probability that a person aged x will live n years [7].

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

2) $_nq_x$ is the probability that a person aged x will die in n years [7].

$$_nq_x = \frac{l_{x+n}}{l_x} \tag{2}$$

The commutation symbol is a symbol used to simplify the calculation of the mortality table on an annuity or series of payments.

1) D_x Symbol [7].

$$D_x = v^x l_x \tag{3}$$

2) N_x Symbol [7].

$$N_x = \sum_{i=0}^{w-x} D_{x+i} \tag{4}$$

D. Annuities

An annuity is a series of periodic payments made by a living person. The value of an annuity is based on mortality. A life annuity is a combination of survival function $_np_x$ and interest function v^n with the following formula [7]:

$$\ddot{a}_x = \frac{N_x}{D_x} \tag{5}$$

E. Benefit Function

Pension benefits are computed as a proportion of the last wage earned using the following equation [6]:

$$B_r = k(r-e)s_{r-1} \tag{6}$$

Where S_{r-1} is the last salary which is at the age $r-1$. Thus, the Present Value Future Benefit can be done by using this equation [6]:

$$^r(PVFB)_x = B_r \ddot{a}_r v^{r-x} {}_{r-x}p_x \tag{7}$$

F. Normal Cost

Normal cost is a contribution paid by the beneficiary using the actuarial valuation method to the pension fund. The normal cost contribution formula for age x is defined as [6]:

$$^r(NC)_x = b_x \ddot{a}_r v^{r-x} {}_{r-x}p_x, \quad y \le x < r \tag{8}$$

With b_x is a large growth in benefits per year when the worker is x years old. Normal cost beneficiary from entry age e until retirement age r is called the Present Value of Future Normal Cost (PVFNC). The formula for PVFNC is defined as [6]:

$$^r(PVFNC)_e = \sum_{t=x}^{r-1} (NC)_t v^{t-x} {}_{t-x}P_x \tag{9}$$

PVFNC value will be equal to the size of the retirement benefit when the entry age e.

G. Actuarial Liability

Actuarial liability is a pension fund liability that is calculated by the assumption that the pension fund will continue until all liabilities of the participants are fulfilled. The general formula is [6]:

$$^r(AL)_x = B_x \ddot{a}_r v^{r-x} {}_{r-x}p_x \tag{10}$$

H. Projected Unit Credit (PUC)

Projected Unit Credit uses the distribution of pension benefits that pension participants will get if they work until they reach normal retirement age with a total of years of service. Hence, the normal cost of PUC is [6]:

$$^{PUC\,r}(NC)_x = \frac{^r(PVFB)_x}{(r-e)} \tag{11}$$

And the actuarial liability of PUC is [6]:

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

III. METHODOLOGY

This study's purposes are to compare the impact of the using of two mortality tables on the value of pension funds using the projected unit credit method. Thus, below is a sequence of how the pension funds calculation is conducted:

1. Prepare a calculation table based on the mortality table rate utilized, with the assumption of 6.25% interest rate.
2. Calculate the amount of pension benefits for each participant based on the salary on the evaluation time, given the entry age of each participant, the last salary before retirement, with an assumption of 8% salary increase rate, retirement benefit (k) of 2.5%, and all participants are assumed to retire at 58 years old.
3. Calculate the present value of the retirement benefit $^r(PVFB)_x$, based on the amount of pension benefits, the initial lifetime annuity at retirement age, the discount factor, and the chance of someone living to n years.
4. Calculate actuarial liability and normal cost with the projected unit credit method.

IV. RESULTS

A.   Data Preparation

The data in this study is the wages data of PT XYZ's employees. All employees will retire at the age of 58, the assumption is based on the retirement age of civil service employees in Indonesia [4]. The interest rate used is 6.25% assumed from the BI rate on June 2024 [5]. Wages data of PT XYZ's employees

TABLE 1
WAGES DATA OF PT XYZ'S EMPLOYEES

No	Gender	Age on Evaluation (x)	Years of Service	Basic Salary	Entry Age (e)
1	M	55	28	18,336,000	27
2	M	50	28	18,651,000	22
3	M	54	31	19,436,000	23
4	M	54	31	18,906,000	23
5	F	56	33	18,298,900	23
6	M	51	29	18,223,500	22
7	M	50	28	18,165,400	22
8	M	56	33	16,481,000	23
9	M	54	31	15,661,000	23
10	M	44	23	15,661,000	21
11	M	52	27	15,481,000	25
12	M	53	28	12,549,000	25
13	M	56	33	14,117,500	23
14	F	56	33	14,117,500	23
15	M	55	32	14,117,500	23
16	M	55	32	14,715,400	23
17	F	53	29	14,117,500	24
18	F	51	25	14,117,500	26
19	M	49	25	14,059,400	24
20	M	49	27	13,944,800	22
21	F	41	17	13,824,500	24
22	M	47	32	11,674,000	15
23	M	51	25	11,424,000	26
24	M	54	30	11,425,500	24

25	M	52	27	11,648,400	25
26	F	51	26	11,333,200	25
27	M	51	27	11,477,500	24
28	M	53	29	10,761,000	24
29	M	51	26	9,949,000	25
30	F	40	10	9,824,000	30
31	M	56	33	10,699,000	23
32	M	53	29	9,949,000	24
33	M	47	17	9,932,000	30
34	F	56	34	9,667,800	22
35	M	54	23	9,563,500	31
36	M	54	32	7,716,000	22
37	M	49	21	7,716,000	28
38	F	45	18	7,738,000	27
39	M	56	32	6,691,000	24
40	M	55	32	6,691,000	23
41	M	49	21	6,329,000	28
42	M	51	23	6,521,000	28
43	M	52	31	6,691,000	21
44	M	48	24	6,329,000	24
45	M	46	23	6,350,000	23
46	M	48	21	6,521,000	27
47	M	49	23	6,521,000	26
48	M	53	30	6,350,000	23
49	M	45	22	5,689,000	23
50	M	48	21	6,691,000	27
51	M	54	32	6,329,000	22

B. Calculation table

The calculation table is made to assess the calculation of pension financing. The calculation table is prepared based on the two mortality tables. The mortality tables used in the research of this article are the Indonesian Mortality Table IV [9] and the BPJS *Ketenagakerjaan* 2022 Mortality Table [8]. An interest rate assumption of 6.25% is used to complete the calculation table.

C. Pension Benefit

Several essential elements are required to determine the amount of pension benefits based on Indonesian Mortality Table IV. The amount of pension benefits is based on the final salary, with a benefit multiplayer (k) of 2.5%. As an example of the calculation, a male employee with a basic salary of Rp 6,691,000.00 joined as a participant at the age of 21 (e) and retire at the age of 58 (r). Meanwhile, a female employee joined as a participant at the age of 22 (e) and retire at the age of 58 (r). The calculation for the male participant at the age of 52 begins with calculating the amount of pension benefits based on the last salary [6].

$B_r = k(r - e)S_{r-1}$
$B_{58} = Rp\ 9,093,929$ s
Calculation of the present value of pension benefits:
$^r(PVFB)_x = B_r \ddot{a}_r v^{r-x}{}_{r-x}p_x$
$^{58}(PVFB)_{52} = B_{58} v^6 \ddot{a}_{58} {}_6P_{52}$
$^{58}(PVFB)_{52} = Rp\ 81,431,257.00$
Thus, the Present Value of Future Benefit (PVFB) at the age of 52 is $Rp\ 81,431,257.00$

D.   Normal Cost Calculation

In calculating normal cost by using the Projected Unit Credit Method, the normal cost value is needed. Using the exact employee's data, thus obtained [6]:

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

$$^{PUC\ 58}(NC)_{52} = \frac{Rp\ 81,431,257.00}{(58 - 21)}$$

$$^{PUC\ 58}(NC)_{52} = Rp\ 2,200,845.00$$

Thus, it is obtained the normal cost of this employee is Rp 2,200,845.00

E.   Actuarial Liability Calculation

To complete the actuarial liability, the entry age, retirement age, evaluation age of the participants, and the Present Value of Future Benefits are needed. Using the exact employee's data, thus obtained [6]:

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

$$^{PUC\ 58}(AL)_{52} = \frac{(52 - 21)}{(58 - 21)} \times Rp\ 81,431,257.00$$

$$^{PUC\ 58}(AL)_{52} = Rp\ 68,226,188.00$$

Thus, it is obtained that the actuarial liability of this employee is $Rp\ 68,226,188.00$

F.   Final Calculation

After going through the several processes above, thus it is obtained the comparison of normal costs using the BPJS mortality table and Indonesian Mortality Table IV:

TABLE 2
NORMAL COST RESULT OF PT XYZ'S EMPLOYEES

Age (x)	NC male		NC Female	
	BPJS	TMI IV	BPJS	TMI IV
21	357881	382130	-	-
22	379347	405194	419321.7836	451400.8553
23	402052	429578	444651.5981	478711.8756
24	426065	455349	471472.4085	507623.3786
25	451453	482585	499865.5957	538221.449
26	478282	511367	529911.8551	570618.5093
27	506626	541782	561699.45	604912.5328
28	536566	573934	595324.429	641205.626
29	568178	607909	630882.057	679590.4115
30	601537	643796	668463.5209	720174.2513
31	636723	681687	708168.0333	763083.2987
32	673825	721690	750105.1833	808435.0056
33	712932	763902	794385.1973	856350.3213
34	754128	808423	841116.5163	906971.5307
35	797514	855351	890424.0458	960429.4052
36	843208	904823	942451.2378	1016877.897
37	891328	956965	997346.5299	1076457.175
38	941978	1011925	1055249.398	1139332.389
39	995278	1069843	1116318.196	1205652.072
40	1051378	1130927	1180739.16	1275591.394
41	1110431	1195362	1248707.934	1349359.389

42	1172581	1263342	1320418.384	1427121.829
43	1238006	1335102	1396108.966	1509134.714
44	1306927	1410866	1476060.633	1595580.283
45	1379573	1490935	1560559.271	1686707.07
46	1456149	1575606	1649875.842	1782814.01
47	1536924	1665237	1744356.889	1884262.62
48	1622267	1760187	1844446.383	1991251.964
49	1712616	1860809	1950627.779	2104095.825
50	1808437	1967481	2063378.798	2223080.579
51	1910353	2080691	2183289.858	2348639.56
52	2019143	2200845	2311081.906	2481147.826
53	2135584	2328553	2447443.576	2621051.943
54	2260290	2464499	2592935.114	2768775.62
55	2393909	2609286	2748248	2924879.905
56	2537188	2763565	2914251	3089852.236
57	2690867	2927678	3091812	3264070.437
58	2855609	3101733	3281647	3447758.434

The results obtained for the comparison of Actuarial Liability using the BPJS mortality table and Indonesian Mortality Table IV:

TABLE 3
COMPARISON OF NORMAL COST USING BPJS MORTALITY TABLE AND INDONESIAN MORTALITY TABLE IV

Age (x)	AL Male		AL Female	
	BPJS	TMI IV	BPJS	TMI IV
21	0	0.00	-	-
22	379347	405,194	0	0
23	804105	859,156	444652	478712
24	1278194	1,366,047	942945	1015247
25	1805811	1,930,338	1499597	1614664
26	2391410	2,556,835	2119647	2282474
27	3039758	3,250,695	2808497	3024563
28	3755959	4,017,539	3571947	3847234
29	4545426	4,863,272	4416174	4757133
30	5413836	5,794,166	5347708	5761394
31	6367229	6,816,874	6373512	6867750
32	7412071	7,938,591	7501052	8084350
33	8555179	9,166,826	8738237	9419854
34	9803661	10,509,493	10093398	10883658
35	11165193	11,974,914	11575513	12485582
36	12648120	13,572,348	13194317	14236291

37	14261252	15,311,436	14960198	16146858
38	16013622	17,202,733	16883990	18229318
39	17915007	19,257,176	18977409	20496085
40	19976178	21,487,622	21253305	22960645
41	22208629	23,907,243	23725451	25637828
42	24624209	26,530,189	26408368	28542437
43	27236134	29,372,243	29318288	31691829
44	30059330	32,449,929	32473334	35102766
45	33109758	35,782,442	35892863	38794263
46	36403725	39,390,153	39597020	42787536
47	39960016	43,296,161	43608922	47106565
48	43801215	47,525,040	47955606	51772551
49	47953242	52,102,642	52666950	56810587
50	52444684	57,056,949	57774606	62246256
51	57310599	62,420,740	63315406	68110547
52	62593435	68,226,188	69332457	74434435
53	68338674	74,513,701	75870751	81252610
54	74589566	81,328,459	82973924	88600820
55	81392894	88,715,722	90692173	96521037
56	88801583	96,724,760	99084523	105054976
57	96871218	105,396,426	108213426	114242465
58	105657549	114,764,136	118139305	124119304

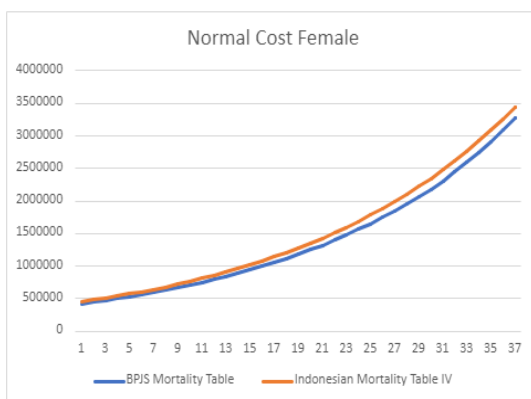As for the graphs that are obtained:

Figure. 1 Comparison of normal cost on female sample.

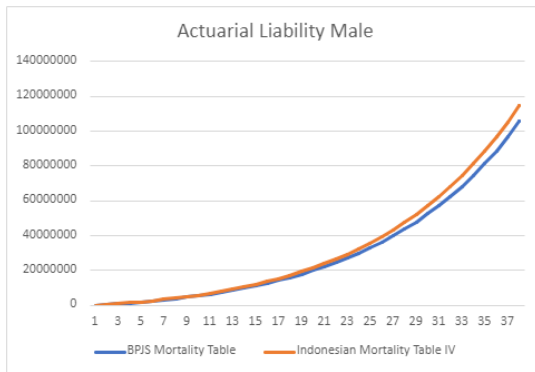Figure. 2 Comparison of normal cost on male sample.

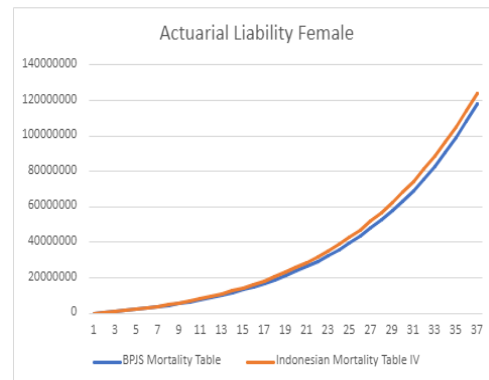Figure. 3 Comparison of actuarial liability on female sample.

Figure. 4 Comparison of actuarial liability on male sample.

The result shows that normal costs and actuarial liabilities experienced various shifts. The shifts grow slowly at the entry age, widen during mid-age, and become larger as retirement approaches. In the normal cost male sample, the difference in value from Indonesian Mortality Table IV and BPJS mortality table is 6.35% at the beginning of entry and increases to 7.94% at retirement age. While the difference in the female sample is 7.11% at the beginning of entry and decreases to 4.82% at retirement age. Thereafter, the actuarial liability male sample, the difference is 6.38% at the beginning of entry and increases to 7.94% at retirement age. For the female sample, it is 7.11% at the beginning of entry and decreases to 4.82% at retirement age.

V. CONCLUSION

Changes in the mortality table in Indonesia are influenced by various factors including shifts in mortality rates, life expectancy, disease patterns, and the effect of pandemics such as COVID-19. In this research, the researchers examined the changes from the Indonesian Mortality Table IV and the BPJS Mortality Table 2022 in pension fund calculation. The data in this research uses salary data from PT.XYZ with the assumption of retirement age at the age of 58, and an interest rate of 6.25%.

As a result of the changes in mortality tables, the normal cost and actuarial liability experienced various shifts. These shifts show that changes in the mortality table will give a wider gap in pension fund calculation at younger ages due to the lower risk of death during that period. However, as individuals approach retirement age, this gap narrows and may even disappear, resulting in similar pension fund calculations for older ages. Furthermore, the normal cost and the actuarial liability have bigger values in Indonesian Mortality Table IV as the impact of the changes on these two mortality tables.

Since this research is limited to calculating the pension fund using the projected unit credit method, further research is expected to use different methods such as the Aggregate Cost method which omits Actuarial Liability in its calculation [11], Attained Age Normal which has the bigger actuarial liability result than Projected Unit Cost [7], or to use the updated Indonesia mortality table, such as Indonesian Mortality Table 2023 to increase the accuracy of the research with the actual condition.

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