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OPTIMIZING DEFINED BENEFIT PENSION PLAN FUNDING: COMBINING ENTRY AGE NORMAL METHOD AND SINGLE SALARY APPROACH

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ABSTRACT

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The sustainability of defined benefit pension plans relies heavily on effective funding strategies. This study aims to develop an optimized funding strategy for Defined Benefit Pension Plans by integrating the Entry Age Normal (EAN) method with the Single Salary Approach (SSA). The Entry Age Normal method provides a systematic way to distribute the cost of pension benefits over the career of employees, ensuring long-term stability. Meanwhile, the Single Salary Approach simplifies salary projections, making it easier to manage fund contributions while accounting for future wage inflation. To evaluate the effectiveness of this integrated approach, we conducted a case study using salary and pension fund data collected from internal records at Institut Teknologi Bacharuddin Jusuf Habibie (ITH), a higher education institution. Through a series of simulations and sensitivity analyses, we demonstrate that integrating these methods not only minimizes funding volatility but also improves the accuracy of pension liabilities estimation. For instance, at age 25.83, the actuarial liability is Rp 38,929,501, reflecting a relatively low liability at a younger age. As employees approach retirement, the liability increases significantly. At age 47.17, the liability reaches Rp 191,823,284, demonstrating the impact of salary growth and length of service on future benefits. Additionally, for the same age of 25.83, the actuarial liability under SSA-EAN is Rp 37,980,001, which is slightly lower than the EAN estimate. Pension benefits projected under SSA-EAN are also slightly lower than those under EAN, indicating potential cost savings. The findings provide a viable framework for pension plan administrators seeking to achieve both financial sustainability and predictability in managing pension obligations. By integrating SSA with EAN, this study offers a practical solution that addresses key challenges in the actuarial valuation of defined benefit plans, ensuring more stable and predictable pension funding.

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1. INTRODUCTION

Defined Benefit (DB) Pension Plans have long been a cornerstone of retirement security, promising a specific payout to retirees based on a formula that typically considers factors such as salary history, years of service, and age at retirement. Unlike Defined Contribution (DC) plans, where the retirement benefit depends on the investment performance of contributions made by or on behalf of the employee, DB plans place the financial risk on the employer or the plan sponsor [1][2] . The guarantee of a predetermined retirement benefit provides a significant advantage in ensuring that retirees have a stable income throughout their retirement years, offering a financial safeguard against longevity risk, which is the risk of outliving one's retirement savings [3]. However, the sustainability of DB pension plans has been a topic of ongoing concern, particularly in light of the financial volatility experienced by many plan sponsors. The challenge lies in adequately funding these plans to meet the future liabilities, which are often uncertain due to factors such as fluctuating interest rates, changes in employee demographics, and salary increases [4]. The actuarial methods used to calculate the required contributions and assess the liabilities are crucial in ensuring that the plan remains adequately funded and able to meet its obligations [5].

Given these challenges, this study aims to develop an optimized funding strategy for DB pension plans by integrating the Single Salary Approach (SSA) with the Entry Age Normal (EAN) method. Specifically, this research seeks to assess whether the combined approach can enhance funding stability and financial predictability by mitigating the volatility associated with salary increases. While both SSA and EAN have been studied independently, their integration remains largely unexplored in the actuarial literature. By addressing this research gap, this study contributes to the existing body of knowledge on pension funding strategies and offers a potential solution for improving the long-term financial sustainability of DB pension plans.

One of the primary challenges in funding DB pension plans is managing the volatility of the required contributions. This volatility arises from the need to match the assets of the pension plan with its liabilities. Given that these liabilities are often projected far into the future, even small changes in the underlying assumptions such as discount rates, mortality rates, or salary growth can lead to significant fluctuations in the calculated funding requirements [6][7][8]. This uncertainty can pose a significant risk to plan sponsors, who may face substantial increases in required contributions during periods of economic downturn or when other financial obligations are pressing. The traditional methods of funding DB pension plans, such as the Entry Age Normal (EAN) method and the Projected Unit Credit (PUC) method, have been widely used due to their ability to provide a systematic approach to funding. The EAN method, in particular, is designed to spread the cost of future benefits evenly over the employee's career, resulting in stable contribution rates that are intended to ensure that the pension plan is fully funded by the time employees retire [9]. However, even with the EAN method, challenges remain, particularly in how to handle salary increases, which can introduce variability into the funding requirements.

The Single Salary Approach (SSA) is proposed as a method to mitigate some of the volatility associated with funding DB pension plans. Under the SSA, the retirement benefit is based on the final salary of the employee, rather than a series of salary increases throughout their career [10]. This approach simplifies the calculation of pension benefits and can provide more predictability in the required contributions. By focusing on the final salary, the SSA reduces the impact of mid-career salary increases, which can otherwise lead to unexpected increases in the pension liability. The integration of the SSA with the EAN method represents a novel approach to optimizing the funding of DB pension plans. By combining the stability of the EAN method with the predictability of the SSA, plan sponsors can potentially achieve a more balanced and manageable funding strategy. This approach can reduce the risk of underfunding during periods of economic stress and provide a clearer picture of the long-term financial obligations of the pension plan [4][11].

The actuarial literature provides extensive discussion on the methods used for funding DB pension plans, with particular focus on the EAN and PUC methods. Studies have shown that the EAN method, while effective in providing stable contribution rates, can still be susceptible to fluctuations in salary increases and changes in actuarial assumptions [12]. For instance, recent research has highlighted the challenges of predicting long-term salary growth, which can vary significantly across different industries and economic conditions. These fluctuations can lead to situations where the plan is either overfunded or underfunded, depending on the accuracy of the salary growth assumptions. The PUC method, on the other hand, calculates the pension benefit based on the employee's service to date and the projected final salary, making it more responsive to changes in salary but also more volatile in terms of contribution requirements [9]. While this method can be beneficial in certain contexts, particularly where salary growth is expected to be irregular, it may not provide the stability that plan sponsors seek [13].

The SSA has been less widely studied in the context of DB pension plans, but its application in other areas of financial planning has demonstrated its potential to reduce complexity and increase predictability. The combination of the SSA with the EAN method offers a promising avenue for future research, particularly in how it can be applied to stabilize pension funding and ensure that liabilities are accurately matched with the plan's assets.

Despite the extensive research on DB pension plan funding, there remains a gap in the literature concerning the integration of the SSA with the EAN method. While both methods have been independently studied, their combination has not been thoroughly explored, particularly in terms of how this integration can optimize the funding strategy for DB pension plans. This study aims to fill this gap by providing a detailed analysis of the combined approach and assessing its effectiveness in reducing funding volatility and ensuring long-term financial stability for pension plans. The objective of this study is to develop a comprehensive model that integrates the SSA with the EAN method, and to test this model using real-world data. By comparing the results of this combined approach with traditional methods, the study seeks to determine whether the integration of SSA and EAN can provide a more effective solution for pension plan funding. The method in this research integrates the Single Salary Approach (SSA) with the Entry Age Normal (EAN) method to develop an optimized funding strategy for Defined Benefit (DB) pension plans. The SSA assumes that salary increases are uniform and stable over time, providing a simplified approach to calculating contributions. The EAN method, on the other hand, spreads the cost of pension benefits over each participant's career, aligning with a stable funding model. By combining these two methods, the study aims to create a more effective model that addresses the inherent risks and funding volatility often associated with DB pension plans. The researchers used real-world data to test the combined model, comparing it against traditional funding methods to assess its impact on funding stability and financial predictability. Additionally, the approach can offer a clearer understanding of the long-term obligations associated with the pension plan, allowing for better financial planning and resource allocation.

2. RESEARCH METHODS

This study employs a quantitative research design using actuarial models to assess the financial impact of combining the EAN method with the SSA. The goal of the research is to calculate and compare pension plan contributions and liabilities under different scenarios, such as varying salary growth rates and discount rates. Simulations are performed to demonstrate how the combined approach provides more stable funding compared to traditional methods.

The data used in this study were collected from internal records at Institut Teknologi Bacharuddin Jusuf Habibie (ITH), including historical salary information for staff and lecturers for the period 2022-2024, including age, years of service, and salary progression Information regarding pension fund contributions, benefit payouts, and actuarial valuations, and Key economic assumptions such as salary growth rates, discount rates, and inflation rates. These assumptions were based on both historical data and projections from official financial and governmental reports.

The analysis involves calculating pension plan liabilities and contributions using the EAN method under both a constant salary scenario and the SSA. Microsoft Excel and actuarial software such as Matlab and Actuarial Valuation Tools were used to perform simulations and analyze the impact of salary and interest rate variations on funding requirements. Sensitivity analysis was conducted to test how changes in assumptions, such as salary growth or discount rates, affect the results. The findings are compared against traditional funding methods to demonstrate the advantages of integrating SSA with the EAN method.

3. RESULTS AND DISCUSSION

Writing the results and discussion can be separated into different subs or can also be combined into one sub. The summary of results can be presented in the form of graphs and figures. The results and discussion sections must be free from multiple interpretations. The discussion must answer research problems, support, and defend answers with results, compare with relevant research results, state the study's limitations, and find novelty.

3.1 Mortality Table

In the mortality table, the number of people aged x is expressed as simbol l_x. While the number of people who died between the ages of x and $x+1$ is expressed by the symbol d_x.

$$D_x = v^x l_x \tag{1}$$

$$N_x = \sum_{i=0}^{w-x} D_{x+i} \tag{2}$$

Table 1. Male Mortality Table 2019

X	q_x	p_x	l_x
0	0.00524	0.99476	100000
1	0.00053	0.99947	99476
2	0.00042	0.99958	99423.27
3	0.00034	0.99966	99381.51
4	0.00029	0.99971	99347.73
5	0.00026	0.99974	99318.91
⋮	⋮	⋮	⋮
109	0.55733	0.44267	10.23656
110	0.59244	0.40756	4.53142

Data source*: Indonesia Mortality Table IV* [14]

Table 1 provides a summary of the male mortality rates and survival probabilities based on data from 2019. This table includes the following columns:

x : Represents the age of the individual in years.

q_x : This is the mortality rate or probability of death between ages x.

p_x : The probability of survival from age x.

l_x : The number of individuals (out of an initial cohort of 100,000) expected to be alive at each age x.

The data provides insights into mortality patterns across different ages, with survival probabilities decreasing and mortality rates increasing as age advances. By age 110, only about 4.53 individuals are expected to remain alive from the initial cohort, reflecting the impact of age on survival. This table is typically used in actuarial science and demographic studies for analyzing life expectancy and mortality risks.

3.2 Normal Entry Age

The benefit function is used to determine the amount of benefit that the company needs to pay for participants when entering retirement age. In this study, the benefit function of participants with retirement age is used r based on the last salary

$$B_t = k(p-y)S_{t-1}$$

With

B_t : Accumulated retirement benefits at age t years

k : Percentage of salary that will go towards retirement benefits

p : Normal retirement age

y : Age of entry into the pension fund

S_{t-1} : Salary before retirement at time $t-1$

The assumption used in this method is that employees are registered in a pension fund program when they start working at aged e years old. Hence, age when they registered as pension funds program participants (a) years old is the age start working $(a = e)$. Supposed that S_e is initial salary, so that the expected present value of cumulative pension funds benefits for someone aged x years old that has been work since aged e years old and will be retire at age r years old are defined by

$$B_r = 12k(r-e)S_e(1+s)^{(r-1-e)}a_r{}^{(12)} \tag{3}$$

Hence, the last salary at age $(r-1)$ years old or a year before the employees retire can be written by:

$$s_{r-1} = S_e(1+s)^{(r-1-e)} \tag{4}$$

One of the key results from the integration of the EAN method and SSA is the significant improvement in contribution stability. The SSA ensures that the pension benefits are based on the employee's final salary, which simplifies the actuarial assumptions regarding salary growth throughout the employee's career. Table 1 illustrates the difference in contribution levels when applying the EAN method with and without SSA under various salary growth scenarios.

Table 2. Salary based on EAN and SSA-EAN

x	EAN	SSA-EAN
25.83	7773073.34	7582486.57
26.08	5662808.77	5524691.48
26.58	9203338.24	8978866.57
26.92	9375625.64	9146951.85
27.00	4262221.66	4158265.04
27.67	4288614.39	4184014.04
⋮	⋮	⋮
43.75	8776252.20	8562197.26
47.17	8704312.47	8492012.16

As shown in Table 2 compares salary estimates based on two approaches: Entry Age Normal (EAN) and the combined Single Salary Approach - Entry Age Normal (SSA-EAN). The values at each age or time point (x) show how the two methods influence salary projections and pension liability. In the EAN column, salary values are generally higher than those in the SSA-EAN column due to the dynamic calculation of salary increases each year. The method accounts for potential growth in salary, leading to variable funding needs throughout an employee's career. In the SSA-EAN column, salary values tend to be slightly lower than those in the EAN column. This is because SSA-EAN assumes a more linear or fixed salary progression, making it easier to calculate pension liabilities without complex salary growth projections. At age 26.58, the estimated salary under EAN is Rp 9,203,338.24, while at age 47.17, it increases to Rp 8,704,312.47. This variation reflects the assumption that salaries increase over time, leading to higher pension contributions as employees advance in their careers. At age 26.58, the estimated salary under SSA-EAN is Rp 8,978,866.57, slightly lower than the EAN estimate. Similarly, at age 47.17, the salary is Rp 8,492,012.16, reflecting a more stable salary assumption compared to the dynamic growth under EAN.

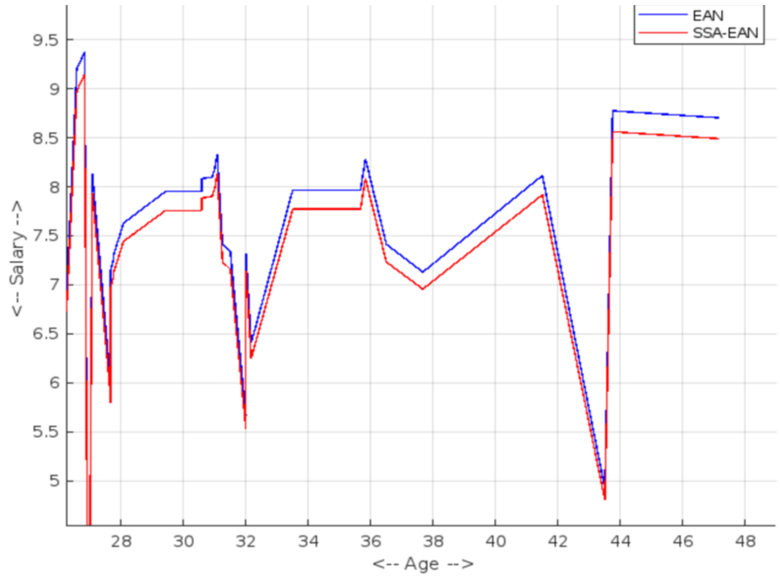

Figure 1. Salary Based on EAN and SSA-EAN

The EAN method exhibits more significant variations in salary projections at different ages because it accounts for salary growth and economic fluctuations. In contrast, SSA-EAN results in more consistent and stable salary projections. While SSA-EAN results in slightly lower salary projections, it simplifies pension fund calculations by reducing the impact of salary growth uncertainty. This stability can benefit long-term pension planning. With SSA-EAN, pension liabilities are easier to predict because of the constant salary assumption. In contrast, EAN provides more variable estimates, reflecting real salary growth trends and their impact on pension funding.

Normal costs are only calculated once at the beginning since the calculations is done when the employees start working, so that the contributions will have the same amount at any time until the employees retire. If the normal costs for someone aged e years old when they start working is determined as follows:

$$^{EAN}NC_e = \left(\frac{D_r}{N_e - N_r}\right) B_r \tag{5}$$

Unlikely normal costs, the actuarial liabilities will not have the same amount. The actuarial liabilities that are calculated when someone aged x years old is

$$^{EAN_r}AL_x = {}^{EAN}NC_e \left(\frac{N_e - N_x}{D_x}\right) \tag{6}$$

In the event where an employee registers at age t after beginning employment, the typical cost will be determined using the formula age $y = e + t$. The calculations cannot use the EAN technique due to the age difference between starting work and registering for pension funds.

When the amount of benefit payout is dependent on the method of leaving the group of active insureds, various decrement models have actuarial applications. The objective is to determine the actuarial present value of benefits that are payable either at the time of death or at the end of the year of death using different decrement models. Assume that the multiple decrement model with k causes of decrement underlies the mortality model [15]. Inflation, length of service, and wage growth are frequently taken into consideration in the benefit calculation. We consider the typical situation in which the benefit is determined by the cause of the decline.

The theory of pension funding in this study will benefit from this strategy. Assume that $\mathcal{B}_{x+t}^{(j)}$ represents the value of a benefit for a redsuction at age $x + t$ due to cause k. The benefit that will be paid at the time of death (x), designated generally by A. We arrive at the following formulation in terms of fundamental operations:

$$FB_{PV}^{(x)} = FNC_{PV}^{(x)}$$

$$ {}^{t}FB_{PV}^{(x)} = \mathcal{B}_t \, {}_{t-x}p_x \, d^{(t-x)} \ddot{a}_t \tag{7}$$

$$= \mathcal{B}_t \frac{k_{x+(t-x)}}{k_x} d^{(t-x)} \ddot{a}_t$$

$$= \mathcal{B}_t \frac{\mathcal{D}_t}{\mathcal{D}_x} d^{(t-x)} \ddot{a}_t$$

$$FB_{PV}^{(x)} = \sum_{r=x}^{t-1} {}_{t-x}p_x^{\eta} \; d^{(r-x)} \, {}^{\mathcal{DT}}_{r} \tag{8}$$

$${}^{\mathcal{DT}}_{r} = {}^{(y)}\beta_r \, \mathcal{B}_r \, g^{(\mathcal{D})} \, d_r \, \ddot{a}_{r+1}$$

$${}^{\mathcal{R}}FB_{PV}^{(x)} = \sum_{r=x}^{t-1} {}_{t-x}p_x^{\eta} \; d^{(r-x)} \, {}^{\mathcal{RT}}_{r} \tag{9}$$

$${}^{\mathcal{RT}}_{r} = {}^{(\mathcal{R})} \beta_r \, \mathcal{B}_r \, g^{(\mathcal{R})} \, d_{r+1}^{(t-r-1)} \, \ddot{a}_r$$

With

${}^{t}FB_{PV}^{(x)}$	:	present value future of normal benefit
${}^{\mathcal{D}}FB_{PV}^{(x)}$	:	present value of death benefit
${}^{(y)}\beta_r$	:	the proportion of the benefit that a beneficiary will receive if the employee dies at age y
${}^{(\mathcal{R})}\beta_r$	:	the proportion of benefit that will be received if the employee withdraws before retirement $\mathcal{R}$
${}^{\mathcal{DT}}_{r}$	:	disability benefit for employee aged r
${}^{\mathcal{RT}}_{r}$	:	the term cost of withdrawal benefit for employee aged r
$g^{(m)}$	:	the proportion of the benefit that the employee will receive if becomes disabled
$g^{(\mathcal{R})}$	:	the proportion of benefit that will be received if the employee withdraws before retirement

The following is the present value of future typical costs multiplied by the total present value of benefits:

$$FNC_{PV}^{(u)} = FB_{PV}^{(u)} + {}^{\mathcal{D}}FB_{PV}^{(u)} + {}^{\mathcal{R}}FB_{PV}^{(u)} \tag{10}$$

The actuarial liabilities calculated using the combined method were also lower and more predictable compared to the traditional EAN method. The SSA focuses on the final salary, reducing the variability in future liabilities that can arise from changes in salary patterns over time. Table 3 shows the actuarial liabilities under different discount rate assumptions.

Table 3. Pension Benefit based on EAN and SSA-EAN

x	EAN	SSA-EAN
25.83	263143742	256725601
26.08	41105938	40103354
26.58	452343440	441310673
26.92	493222568	481192750
27.00	29725028	29000027
27.67	30822715	30070942
⋮	⋮	⋮
43.75	461691391	450430626
47.17	457906865	446738405

EAN is a method commonly used to ensure that the cost of pension benefits is allocated fairly throughout an employee's career. The column under EAN shows the projected pension benefits for employees at different ages. The higher the value in this column, the higher the estimated pension liability due to anticipated salary growth. At age 26.58, the pension benefit is Rp 452,343,440, while at age 47.17, it is Rp 457,906,865. This indicates an increasing liability as employees get closer to retirement, reflecting salary growth and longer periods of service. The SSA-EAN column shows slightly lower pension benefit projections compared to EAN, reflecting the assumption of a stable salary without significant annual increases. At age 26.58, the pension benefit under SSA-EAN is Rp 441,310,673, slightly lower than the EAN estimate. At age 47.17, it is Rp 446,738,405, reflecting the more stable salary assumption compared to EAN. Pension benefits projected under SSA-EAN are slightly lower than those under EAN. This is because the SSA-EAN approach does not account for the dynamic salary growth that is included in EAN calculations. The SSA-EAN approach offers more predictable pension funding, as it does not rely on assumptions about future salary growth. This stability can make it easier for pension fund managers to plan and allocate resources. On the other hand, EAN can provide more realistic projections when significant salary growth is expected, but it introduces more variability and risk into pension funding.

Table 4. Actuarial Liability based on EAN and SSA-EAN

x	EAN	SSA-EAN
25.83	38929501	37980001
26.08	6155845	6005702
26.58	69413838	67720817
26.92	76615744	74747068
27.00	4636210	4523132
27.67	4827002	4709270
⋮	⋮	⋮
43.75	163711494	159718531
47.17	191823284	187144667

At age 25.83, the actuarial liability is Rp 38.929.501, which reflects a relatively low liability at a younger age. As employees age and approach retirement, the liability increases. For instance, at age 47.17, the liability reaches Rp 191,823,284, demonstrating the impact of salary growth and length of service on future benefits. For the same age of 25.83, the actuarial liability under SSA-EAN is Rp 37.980.001, which is slightly lower than the EAN estimate. At age 47.17, the liability is Rp 187.144.667, again lower than the EAN figure due to the assumption of a stable salary. The actuarial liabilities calculated under the EAN method are higher than those under SSA-EAN. This difference is primarily due to EAN's assumption of increasing salaries over time, which directly impacts the future pension payouts. Both methods show an increase in actuarial liability as employees age, but EAN shows a more pronounced increase due to salary growth assumptions. For instance, at age 43.75, EAN shows a liability of Rp 163.711.494, compared to Rp 159.718.531 for SSA-EAN. SSA-EAN provides a more stable and predictable estimate of future liabilities, which can simplify financial planning for pension funds. However, it may not accurately reflect the true liabilities if significant salary increases are anticipated.

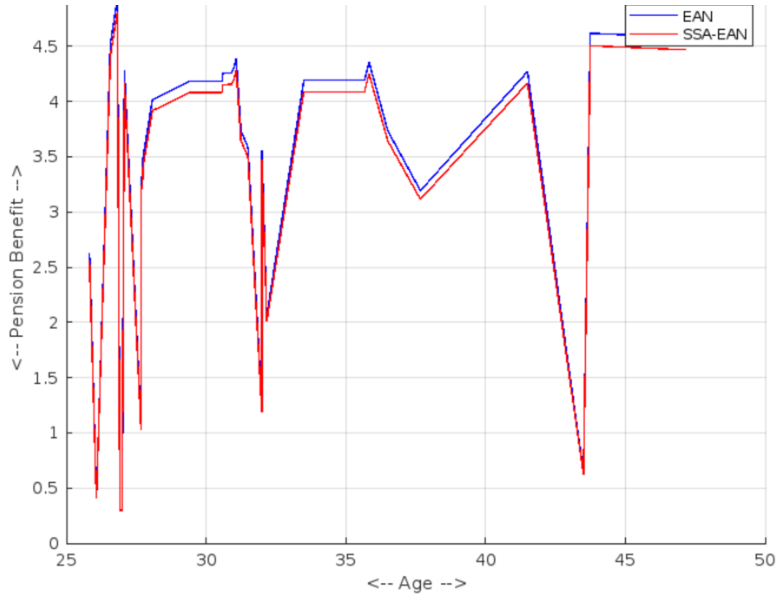

Figure 2. Pension Benefit Based on EAN and SSA-EAN

Sensitivity analysis was conducted to evaluate the impact of changes in key assumptions, such as salary growth and discount rates, on the combined method. The results show that the SSA method is less sensitive to fluctuations in salary growth, leading to a more stable funding requirement over time. In contrast, the traditional EAN method shows higher sensitivity to salary changes, causing fluctuations in both contribution levels and liabilities [16]. The primary advantage of combining the EAN method with SSA is the increased stability it offers in contribution levels and actuarial liabilities. Traditional actuarial methods that account for ongoing salary increases throughout an employee's career can lead to unpredictable funding requirements, particularly in environments with volatile salary growth. The SSA mitigates this risk by simplifying the benefit calculation to the employee's final salary, which is generally more stable and easier to predict.

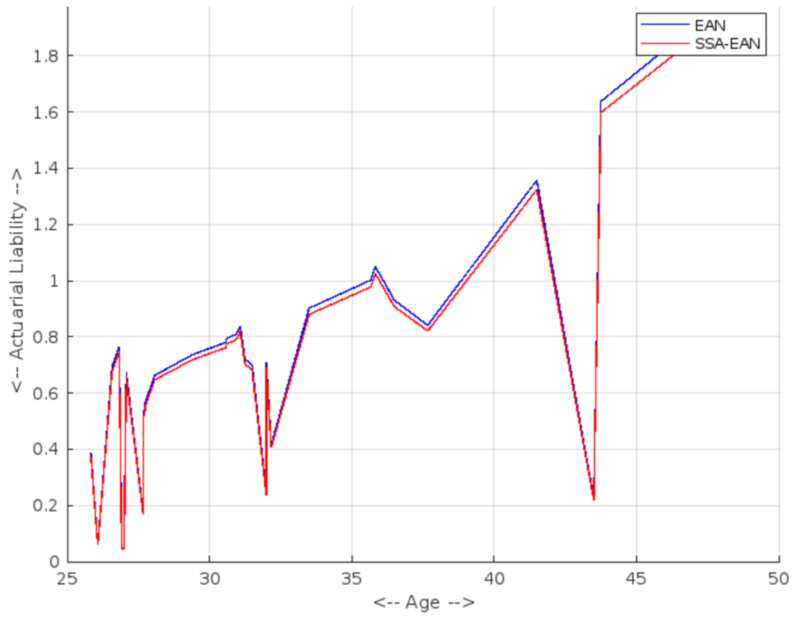

Figure 3. Actuarial Liability Based on EAN and SSA-EAN

Furthermore, the combined method ensures that contributions remain level throughout the employee's working life. This aligns with the goals of many plan sponsors who seek to minimize year-to-year fluctuations in funding requirements [17]. The use of SSA as a final salary benchmark for pension benefits also addresses the issue of underfunding, as it reduces the actuarial liability variability by removing uncertainty about future salary changes. For pension plan sponsors, the EAN-SSA method offers a way to manage their financial obligations more effectively. By stabilizing contribution requirements and reducing the sensitivity of liabilities to salary growth, plan sponsors can improve long-term financial planning. This is especially beneficial for organizations operating in industries where salary growth is difficult to predict or control. The SSA also aligns with regulatory requirements for plan funding, as it ensures that the plan is adequately funded based on known variables. This predictability reduces the risk of underfunding, which could lead to regulatory penalties or increased future contributions [18].

4. CONCLUSIONS

This study has explored the integration of the Entry Age Normal (EAN) method with the Single Salary Approach (SSA) to optimize the funding of Defined Benefit (DB) Pension Plans. The combination of these methods provides several key advantages, which can significantly improve the management and sustainability of pension plan funding. The integration of the EAN method with the SSA has been shown to significantly stabilize contribution levels. By basing pension benefits on the final salary rather than projecting continuous salary growth over an employee's career, the SSA simplifies the funding process and reduces the volatility in required contributions. This stability is particularly beneficial for plan sponsors in managing long-term financial commitments.

The study demonstrated that the combined approach leads to a reduction in the variability of actuarial liabilities. By fixing pension benefits to the final salary, the SSA reduces the uncertainty associated with future salary growth assumptions. As a result, the calculated liabilities are more predictable, which helps pension plan sponsors better plan for future funding needs and minimize the risk of underfunding. The EAN-SSA method offers a practical solution for organizations seeking to minimize the financial risk associated with DB Pension Plans. It is particularly effective in industries where salary growth is stable and predictable.

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