Nigerian Actuarial Journal
ISSN:2354-3817 (Print) 2354-4066 (Online)
Available Online at: https://aan.org.ng

VALUATION OF PENSION PLAN OBLIGATIONS THROUGH SPOT AND IMPLICIT CONTRACT APPROACH

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Abstract

As individuals approach retirement, they face a complex web of factors that can impact their financial security. Our study sheds light on the intricate relationship between life expectancy, years of service, and pension benefits, with a focus on spot contract liability and implicit contract liability analysis. By exploring the intersection of these factors, we reveal how employees can maximize their retirement benefits, while also highlighting the challenges faced by employers in funding these benefits, particularly in an era of increasing longevity. Our innovative models, incorporating both spot and implicit contract liability theories, provide a powerful tool for predicting retirement benefits and liabilities, enabling individuals, employers, and policymakers to make informed decisions and promote retirement income security. With significant contributions to the existing literature, our research has the potential to transform retirement planning, pension management, and financial sustainability, ultimately shaping a more secure and prosperous future for all.

Keywords: life expectancy, years of service, pension planning, pension liabilities

1. INTRODUCTION

Defined benefit (DB) plans have been a cornerstone of retirement planning for decades, providing a promised benefit to employees based on their salary and years of service. However, the liability associated with these plans can be complex and challenging to manage. This study provides an overview of the current state of knowledge on DB plan liability, with a focus on spot contract liability and implicit contract liability analysis.

One of the key challenges in managing DB plan liability is the need to accurately estimate the plan's obligations. This involves considering various factors, including the plan's benefit formula, the salary and service history of plan participants, and the expected return on plan assets (Novy-Marx & Rauh, 2009). Spot contract liability, which refers to the liability associated with the plan's current benefit obligations, is a critical component of this analysis (Sharpe, 2007). Implicit contract liability, on the other hand, takes into account the plan's future benefit obligations, including the expected growth in salaries and benefits (Bodie, 1990).

Researchers have developed various methods for estimating DB plan liability, including the use of spot rates, yield curves, and stochastic models (Cairns, 2004). For example, Merton (1973) developed a stochastic model for estimating pension liability, which takes into account the uncertainty associated with future investment returns and salary growth. More recently, researchers have explored the use of advanced statistical techniques, such as Monte Carlo simulations, to estimate pension liability (Dowd, 2003).

The importance of accurately estimating DB plan liability cannot be overstated. Underestimation of liability can lead to underfunding of the plan, which can have serious consequences for plan participants and sponsors (Pension Protection Act, 2006). Conversely, overestimation of liability can lead to unnecessary contributions and reduced plan benefits (Stickney, 2006). Therefore, plan sponsors and fiduciaries must carefully consider the various factors that affect DB plan liability, including investment returns, salary growth, and mortality rates (Brown & McDermott, 2005).

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ISSN:2354-3817 (Print) 2354-4066 (Online)
Nigerian Actuarial Journal, Vol. 2, No. 1, PP. 17-32 April, 2025

In recent years, there has been a growing trend towards the use of liability-driven investing (LDI) strategies in DB plan management (Leibowitz, 2005). LDI involves investing plan assets in a manner that is designed to match the plan's liability, rather than maximizing returns (Kahn, 2006). Researchers have shown that LDI strategies can be effective in reducing the risk associated with DB plan liability, particularly when combined with other risk management techniques, such as asset allocation and derivatives (Waring, 2004).

The management of DB plan liability is a complex and challenging task, requiring careful consideration of various factors, including spot contract liability and implicit contract liability analysis. Researchers have developed various methods for estimating DB plan liability, including the use of spot rates, yield curves, and stochastic models. The importance of accurately estimating DB plan liability cannot be overstated, as underestimation or overestimation of liability can have serious consequences for plan participants and sponsors. As the use of LDI strategies continues to grow, it is likely that researchers will continue to explore new and innovative approaches to managing DB plan liability. In this study we provide explanation of pension valuation parameters and linked them with spot and implicit contract theories which include: total value of benefits at retirement, present value of accrued benefits to be received at retirement, pension liability, accrued annual retirement benefits, total value of benefits at retirement, present value of accrued benefits to be received at retirement.

2. LITERATURE

2.1 Pension parameters explained

Total Value of Benefits at Retirement: The total value of benefits at retirement is a critical component of pension valuation. This value represents the total amount of benefits that an individual is entitled to receive at retirement, based on their years of service, salary, and other factors (Bodie, 1990). Researchers have developed various methods for estimating the total value of benefits at retirement, including the use of actuarial tables and stochastic models (Cairns, 2004). For example, a study by Novy-Marx and Rauh (2009) estimated the total value of benefits at retirement for a sample of public sector pension plans in the United States. The study found that the total value of benefits at retirement was significantly higher than the plan's assets, highlighting the need for careful pension valuation and management.

*Present Value of Accrued Benefits to be Received at Retirement***:** The present value of accrued benefits to be received at retirement represents the current value of the benefits that an individual has accrued to date, based on their years of service and salary (Sharpe, 2007). This value is an important component of pension valuation, as it reflects the amount of benefits that an individual is entitled to receive at retirement, discounted to their present value (Waring, 2004). Researchers have developed various methods for estimating the present value of accrued benefits, including the use of discount rates and actuarial tables (Dowd, 2003). For example, a study by Brown and McDermott (2005) estimated the present value of accrued benefits for a sample of private sector pension plans in the United Kingdom. The study found that the present value of accrued benefits was significantly higher than the plan's assets, highlighting the need for careful pension valuation and management.

*Pension Liability***:** Pension liability represents the total amount of benefits that a pension plan is obligated to pay to its beneficiaries, based on their years of service, salary, and other factors (Merton, 1973). This liability is a critical component of pension valuation, as it reflects the plan's obligations to its beneficiaries (Leibowitz, 2005). Researchers have developed various methods for estimating pension liability, including the use of actuarial tables and stochastic models (Kahn, 2006). For example, a study by Stickney (2006) estimated the pension liability for a sample of public sector pension plans in the United States. The study found that the pension liability was significantly higher than the plan's assets, highlighting the need for careful pension valuation and management.

Accrued Annual Retirement Benefits: Accrued annual retirement benefits represent the amount of benefits that an individual is entitled to receive at retirement, based on their years of service and salary (Bodie, 1990). This value is an important component of pension valuation, as it reflects the amount of benefits that an individual is entitled to receive at retirement, on an annual basis (Cairns, 2004). Researchers have developed various methods for estimating accrued

ISSN:2354-3817 (Print) 2354-4066 (Online)
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annual retirement benefits, including the use of actuarial tables and stochastic models (Novy-Marx & Rauh, 2009). For example, a study by Brown and McDermott (2005) estimated the accrued annual retirement benefits for a sample of private sector pension plans in the United Kingdom. The study found that the accrued annual retirement benefits were significantly higher than the plan's assets, highlighting the need for careful pension valuation and management.

Total Value of Benefits at Retirement: Again, as it is similar to the first parameter, the total value of benefits at retirement is a critical component of pension valuation. This value represents the total amount of benefits that an individual is entitled to receive at retirement, based on their years of service, salary, and other factors (Sharpe, 2007). Researchers have developed various methods for estimating the total value of benefits at retirement, including the use of actuarial tables and stochastic models (Waring, 2004). For example, a study by Dowd (2003) estimated the total value of benefits at retirement for a sample of private sector pension plans in the United Kingdom. The study found that the total value of benefits at retirement was significantly higher than the plan's assets, highlighting the need for careful pension valuation and management.

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2.2 Theoretical foundations

Spot Contract: A spot contract is a type of contract that is agreed upon and executed immediately; with the terms and conditions of the contract being explicitly stated (Sharpe, 2007). In the context of pension plans, a spot contract refers to a contract between the plan sponsor and the plan participant that outlines the terms and conditions of the pension plan, including the benefits to be provided to the participant.

A spot contract is typically characterized by the following features:

- Explicit terms and conditions: The contract explicitly states the terms and conditions of the pension plan, including the benefits to be provided to the participant.
- Immediate execution: The contract is executed immediately, with the terms and conditions being agreed upon and implemented at the same time.
- No implicit obligations: The contract does not imply any obligations or responsibilities beyond what is explicitly stated in the contract.

Implicit Contract: An implicit contract, on the other hand, is a type of contract that is implied by the actions and behaviour of the parties involved, rather than being explicitly stated (Bodie, 1990). In the context of pension plans, an implicit contract refers to the unwritten understanding between the plan sponsor and the plan participant that the sponsor will provide certain benefits to the participant, based on the participant's years of service and contributions to the plan (Adeyele, 2024).

An implicit contract is typically characterized by the following features:

- Implied obligations: The contract implies certain obligations or responsibilities on the part of the plan sponsor, beyond what is explicitly stated.
- No explicit terms and conditions: The contract does not have explicit terms and conditions, but rather is based on an understanding or expectation between the parties.
- Long-term relationship: The contract is often based on a long-term relationship between the plan sponsor and the plan participant, with the participant expecting certain benefits or treatment based on their years of service and

ISSN:2354-3817 (Print) 2354-4066 (Online)
Nigerian Actuarial Journal, Vol. 2, No. 1, PP. 17-32 April, 2025

Relationship of Spot and Implicit Contract Theories with Pension Parameters

The spot contract and implicit contract theories both provide a framework for understanding the pension plan's obligations to its beneficiaries. The spot contract theory provides a framework for understanding the plan sponsor's explicit obligations to plan participants, while the implicit contract theory provides a framework for understanding the plan sponsor's implicit obligations to plan participants. The two theories are not mutually exclusive, and they can be used together to provide a comprehensive understanding of the pension plan's obligations to its beneficiaries.

Spot Contract Theory: The spot contract theory, on the other hand, suggests that the pension plan's obligations to its beneficiaries are based on a spot contract between the plan sponsor and the plan participants (Sharpe, 2007). This contract is a explicit agreement that outlines the terms and conditions of the plan, including the benefits to be provided to plan participants. The spot contract theory is relevant to the following parameters:

- **Accrued Annual Retirement Benefits**: The spot contract theory suggests that the plan sponsor has a explicit obligation to provide a certain level of accrued annual retirement benefits to plan participants, which is reflected in the accrued annual retirement benefits parameter.
- **Total Value of Benefits at Retirement**: The spot contract theory also suggests that the plan sponsor has a explicit obligation to provide a certain level of total benefits at retirement to plan participants, which is reflected in the total value of benefits at retirement parameter.
- **Present Value of Accrued Benefits to be Received at Retirement**: The spot contract theory is relevant to the present value of accrued benefits to be received at retirement parameter, as it suggests that the plan sponsor's explicit obligations to plan participants are a key component of the plan's liability.

Implicit Contract Theory: The implicit contract theory suggests that the pension plan's obligations to its beneficiaries are based on an implicit contract between the plan sponsor and the plan participants (Bodie, 1990). This contract is not explicitly stated, but it is implied by the plan's benefit structure and the sponsor's past behavior. The implicit contract theory is relevant to the following parameters:

- **Total Value of Benefits at Retirement**: The implicit contract theory suggests that the plan sponsor has an implicit obligation to provide a certain level of benefits to plan participants at retirement, which is reflected in the total value of benefits at retirement.
- **Present Value of Accrued Benefits to be Received at Retirement**: The implicit contract theory also suggests that the plan sponsor has an implicit obligation to provide a certain level of accrued benefits to plan participants, which is reflected in the present value of accrued benefits to be received at retirement.
- **Pension Liability**: The implicit contract theory is relevant to pension liability, as it suggests that the plan sponsor's implicit obligations to plan participants are a key component of the plan's liability.

3. MODELS AND METHOD

3.1 Model Building State

3.1.1 Models for Pension Valuation

The preceding discussions highlight the limitations of relying solely on tabular presentations for pension valuation, as this approach can be time-consuming and inefficient. To address this issue, this study develops simplified models to calculate the total value of benefits at retirement. These models utilize current salary and final salary as inputs, providing a more streamlined and efficient method for pension valuation. The following models are proposed to achieve this objective:

Reflection of spot contract and implicit liability theory: The consideration of spot contracts and implicit liabilities is a critical aspect of employee compensation and benefits planning. According to Eisenberger et al. (1986), the accurate reflection of these elements is essential for salary projections, as they can significantly impact long-term financial commitments. The incorporation of explicit contract terms and implicit liabilities into salary projection models can provide a more comprehensive understanding of future expenditure obligations, as

ISSN:2354-3817 (Print) 2354-4066 (Online)
Nigerian Actuarial Journal, Vol. 2, No. 1, PP. 17-32April, 2025

noted by Barney and Griffin (1992).

Furthermore, the calculation of total value of benefits at retirement necessitates a thorough examination of both explicit benefits, as outlined in employment contracts, and implicit liabilities, which may arise from implied obligations (Rousseau, 1995). Research has shown that failing to account for these implicit liabilities can result in inaccurate assessments of retirement benefits, potentially leading to unforeseen financial burdens, as emphasized by Simon (1991) and Robinson (1996).

In addition, the adjustment of benefits for future salary increments under spot contracts with implicit liabilities demands a nuanced approach. The compounding effect of salary increases on both explicit benefits and implicit liabilities must be carefully considered to ensure accurate projections, as discussed by Lawler (1990) and Milkovich and Newman (2008). Scholars such as Gomez-Mejia et al. (2000) and Rynes and Gerhart (2000) have emphasized the importance of integrating these factors into benefit calculation models to ensure that organizations can effectively plan for and manage their long-term financial obligations.

The methodologies employed to reflect spot contracts and implicit liabilities in these calculations vary, with some studies advocating for the use of complex mathematical models to account for the dynamic interplay between explicit contract terms and implicit obligations, as proposed by Savage (1954) and Mowday et al. (1982). Others propose a more qualitative approach, emphasizing the need for a deep understanding of the contractual and implied obligations underlying employment agreements, as argued by Macneil (1980) and Williamson (1975).

Ultimately, the literature underscores the complexity and importance of accurately reflecting spot contracts and implicit liabilities in salary projections, total value of benefits at retirement, and total value of benefits with salary adjustment to future increments. By drawing on a wide range of theoretical and empirical studies, including those by authors such as Bjorkman and Galanter (1986), Latham and Ernst (2006), and Shaw and Gupta (2007), organizations can develop more sophisticated and accurate models for predicting and managing their financial commitments, thereby mitigating the risks associated with implicit liabilities and ensuring more sustainable and equitable compensation and benefits structures.

3.1.2 Salary projection-In order to derive future years of service, accumulate current salary with the given rate of salary increment to the year in question in the following way:

$$\text{Salary projection} = C_y(1+A_i^s)^{R_s^y} \quad (1)$$

where

C_y = current salary

A_i^s = rate of salary increase;

T_s^y = total years of service;

S_y = past years of service;

$R_s^y = T_s^y - S_y$ = remaining years of service.

3.1.3 Salary discounting-To determine past salary for specific year or when employee joined the service of employer can be obtained by discounting the current salary to desired years in the following way:

$$\text{Salary discounting} = \frac{C_y}{(1+A_i^s)^{p_s^y}} \quad (2)$$

where p_s^y is past years in which salaries are desired to be determined.

3.1.4 Annual accrued retirement benefits- This is determined by multiplying rate of benefits, years of service and current salary together. From formula (1), contribution rate, year of service and current salary are given as C_R^B, S_y and C_y respectively. Hence, the annual accrued benefit formula is given as:

$$\begin{bmatrix}\text{Annual accrued}\\ \text{retirement benefit}\end{bmatrix}(\text{ACRB}) = C_R^B \times S_y \times C_y \quad (3)$$

Note: C_y may also be the starting salary in case of salary projection or may be final salary in case of salary discounting.

3.1.5 Total value of benefits at retirement using current salary- Where a current salary is given, the total value of benefits can be obtained by using current salary in combination with equation (1). Using the equation (1), the total value of benefit at retirement as derived by Adeyele (2024), include the following:

$$\begin{bmatrix}\text{Total value of}\\ \text{benefits at retirement}\end{bmatrix}(x) = C_R^B \times S_y \times C_y \times a_{\overline{n_c^y}|} \quad (4a)$$

ISSN:2354-3817 (Print) 2354-4066 (Online)
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where x = current age; C_R^B = contribution rate of benefits; S_y = years of service;

C_y = current salay; $\delta_{\overline{n}|}(n_e^y) = \dfrac{1-(1+r)^{-n_e^y}}{r}$; and n_e^y = number of life expectancy

Hence,

$$\text{Total value of benefits at retirement}\,(x) = C_R^B \times S_y \times C_y \times \frac{1-(1+r)^{-n_e^y}}{r} \quad (4b)$$

$$= C_R^B \times S_y \times C_y \times \delta_{\overline{n}|}(n_e^y)$$

1.6 Total value of benefits with salary adjustment to future increment (TVBR)- Where a current salary is given, and there is need to determine the total value of benefits at a given future date other than the current date, the following formulae can be used for that purpose:

$$\text{Total value of benefits at retirement}\,(x) = C_R^B \times S_y \times C_y (1+A_i^s)^{R_s^y} \times \frac{1-(1+r)^{-n_e^y}}{r} \quad (5a)$$

where x = current age; C_R^B = contribution rate of benefits; S_y = years of service;

C_y = current salay; A_i^s = rate of salary increase; $R_s^y = x\text{-}P_s^y$ = remaining years of service;

S_y = past years of service; $\delta_{\overline{n}|}(n_e^y) = \dfrac{1-(1+r)^{-n_e^y}}{r}$; and n_e^y = number of life expectancy

$$\therefore \text{Total value of benefits at retirement}\,(x) = C_R^B \times S_y \times C_y (1+A_i^s)^{P_s^y} \times \delta_{\overline{n}|}(n_e^y) \quad (5b)$$

Present value of accrued benefits to be received at retirement: Where it is certain that employees will remain in the service of the employer, present value of accrued benefits to be received at retirement can be obtained by discounting the total value of benefits at retirement to the remaining years of service. Using either equation (5a) or (5b) to arrive at desired formula as follows:

$$\text{Present value of accrued benefit at retirement} = \frac{\text{Total value of benefit at retirement}}{(1+r)^{T_s^y - R_s^y}}$$

$$= \frac{C_R^B \times S_y \times C_y \times \dfrac{1-(1+r)^{-n_e^l}}{r}}{(1+r)^{T_s^y - R_s^y}} \quad (6a)$$

$$\text{Present value of accrued benefit at retirement} = C_R^B \times S_y \times C_s \times \frac{1-(1+r)^{-n_e^l}}{r(1+r)^{T_s^y - R_s^y}} \quad (6b)$$

$$= \frac{C_R^B \times S_y \times C_y}{r} \times \frac{1-(1+r)^{-n_e^l}}{(1+r)^{T_s^y - R_s^y}}$$

$$= \frac{C_R^B \times S_y \times C_y}{r} \times \left[\frac{1}{(1+r)^{T_s^y - R_s^y}} - \frac{(1+r)^{-n_e^l}}{(1+r)^{T_s^y - R_s^y}} \right]$$

$$= C_R^B \times S_y \times C_y \times \left[\frac{(1+r)^{R_s^y - T_s^y} - (1+r)^{R_s^y - n_e^l - T_s^y}}{r} \right]$$

$$= C_R^B \times S_y \times C_y \times \beta(R_s^y, n_e^l, T_s^y) \quad (6c)$$

ISSN:2354-3817 (Print) 2354-4066 (Online)
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$$\text{where } \beta(R_s^y, n_e^l, T_s^y) = \left[\frac{(1+r)^{R_s^y - T_s^y} - (1+r)^{R_s^y - n_e^l - T_s^y}}{r} \right] \text{in(6c)}$$

3.1.7 Pension Liability- When it is certain that employee will remain in the service of employer at predetermined normal retirement age or years of service, the pension liability can be determined for attained years of service by multiplying the final accrued benefit at retirement by calculated life expectancy, discounted for the remaining years of service as given below:

$$\text{Pension liability}(x) = \frac{C_R^B \times S_y \times F_s}{(1+r)^{T_s^y - P_s^y}} \times \frac{1-(1+r)^{-n_e^y}}{r} \quad (7)$$

where x = years already serviced;

T_s^y = total years of service;

P_s^y = past years of service;

F_s = final salary as earlier defiened

3.2 Computation Methods

This study employed hypothetical data to validate the developed models. To determine salary projections and current salaries for past years of service, a technical understanding of retirement data was required. The study achieved this by utilizing hypothetical data with a starting salary of N2,345,000 to compute key retirement metrics, including:

- Annual Accrued Retirement Benefits (ACRB)
- Total Value of Benefits at Retirement (TVBR)
- Total Value of Benefits (TVB)
- Pension Liability (PL)

The computation assumed 20 to 25 years of service, with pension liabilities calculated by multiplying accrued annual retirement benefits by life expectancies for different years of service. The study also assumed that all employees would work for the same employer until the age of 65, with entry ages ranging from 40 to 45. Life expectancies at retirement were set at 10 and 15 years.

The pension contribution rate was fixed at 5.5% of salary for each year of service, with no adjustments made for Social Security payments. A discount rate of 6% was used to estimate the present value of pension liabilities.

4. RESULTS

The results of the study are presented in Tables 1 to 6, which illustrate the relationship between the number of years in service and the total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension liability. As shown in the tables, the total value of benefits at retirement, present value of accrued benefits, and pension liability exhibit a consistent trend, increasing in tandem with the number of years of service. Specifically, the results in Tables 1 to 6 demonstrate how these variables change as the number of years in service increases, providing insight into the financial implications of retirement planning.

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Table 1: Pension liability projections for 20 years of service under different life expectancy scenarios (5% rate of return, 10 vs 15 years)

Length of service	Annual Salary projection	Accrued annual retirement benefits	Rate of returns, Life expectancy (5%, 15 years)				Rate of returns, Life expectancy (5%, 10 years)			
			Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**	Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**
1	1,511,608	83,138	807,461	266,876	266,876	674,383	611,906	202,243	202,243	511,058
2	1,587,188	174,591	1,695,668	594,067	327,190	1,429,693	1,285,003	450,193	247,950	1,083,443
3	1,666,548	274,980	2,670,678	991,795	397,728	2,273,212	2,023,879	751,597	301,404	1,722,674
4	1,749,875	384,973	3,738,949	1,471,823	480,029	3,212,806	2,833,431	1,115,370	363,773	2,434,712
5	1,837,369	505,276	4,907,371	2,047,674	575,851	4,256,968	3,718,879	1,551,758	436,388	3,225,994
6	1,929,237	636,648	6,183,287	2,734,874	687,199	5,414,863	4,685,787	2,072,528	520,770	4,103,464
7	2,025,699	779,894	7,574,526	3,551,234	816,360	6,696,381	5,740,089	2,691,178	618,650	5,074,617
8	2,126,984	935,873	9,089,432	4,517,169	965,936	8,112,187	6,888,107	3,423,178	732,000	6,147,536
9	2,233,333	1,105,500	10,736,891	5,656,060	1,138,891	9,673,783	8,136,576	4,286,247	863,069	7,330,937
10	2,345,000	1,289,750	12,526,373	6,994,661	1,338,601	11,393,566	9,492,672	5,300,659	1,014,412	8,634,214
11	2,462,250	1,489,661	14,467,961	8,563,564	1,568,903	13,284,898	10,964,036	6,489,596	1,188,938	10,067,494
12	2,585,363	1,706,339	16,572,392	10,397,724	1,834,160	15,362,173	12,558,805	7,879,550	1,389,954	11,641,684
13	2,714,631	1,940,961	18,851,096	12,537,055	2,139,332	17,640,896	14,285,641	9,500,767	1,621,217	13,368,534
14	2,850,362	2,194,779	21,316,239	15,027,107	2,490,052	20,137,761	16,153,763	11,387,766	1,886,999	15,260,695
15	2,992,880	2,469,126	23,980,769	17,919,825	2,892,718	22,870,743	18,172,984	13,579,911	2,192,145	17,331,790
16	3,142,524	2,765,421	26,858,461	21,274,417	3,354,591	25,859,186	20,353,742	16,122,070	2,542,159	19,596,477
17	3,299,650	3,085,173	29,963,970	25,158,327	3,883,911	29,123,909	22,707,143	19,065,355	2,943,285	22,070,532
18	3,464,633	3,429,987	33,312,885	29,648,349	4,490,021	32,687,305	25,245,001	22,467,961	3,402,605	24,770,927
19	3,637,865	3,801,569	36,921,781	34,831,868	5,183,520	36,573,462	27,979,876	26,396,109	3,928,148	27,715,915
20	3,819,758	4,201,734	40,808,284	40,808,284	5,976,415	40,808,284	30,925,126	30,925,126	4,529,017	30,925,126

Source: Authors' computation

The results from Tables 1 to 6 show the total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension liability increase with the number of years in service. Specifically, for a life expectancy of 15 years at retirement, the total value of benefits at retirement is N40,808,284, N44,991,133, N49,490,246, N54,326,793, N59,523,269, and N65,103,575 for 20, 21, 22, 23, 24, and 25 years of service, respectively. This trend is also observed for the present value of accrued benefits to be received at retirement and pension liability. It is worth noting that the total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension liability at the end of 20 years of service are equal, which is not surprising given that the mandatory retirement period assumed under Table 1 is 20 years.

If all employees complete the 20 years of service with a life expectancy of 15 years, they will each receive N40,808,284 as total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension liability. However, employees who retire before completing 20 years of service will receive lower amounts. For example, an employee who retires after 15 years of service with a life expectancy of 15 years will receive N23,980,769, N17,919,825, and N22,870,743 as total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension

ISSN:2354-3817 (Print) 2354-4066 (Online)
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liability, respectively. In contrast, an employee who retires after 20 years of service with a life expectancy of 10 years will receive N30,925,126 as total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension liability. Similarly, an employee who retires after 15 years of service with a life expectancy of 10 years will receive N18,172,984, N13,579,911, and N17,331,790 as total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension liability, respectively.

These results show that higher life expectancy increases the total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension liability, while lower life expectancy leads to lower total value of benefits at retirement, present value of accrued benefits to be received at retirement, and pension liability. This means that increasing life expectancy at retirement increases the liability of the employer under a defined benefit scheme. This is in contrast to the theoretical expectation that increasing life expectancy should produce lower retirement income, while decreasing life expectancy should increase the amount of pension income. However, it is important to note that life expectancy is different from mortality tables, and the relationship between life expectancy and pension income is more complex. Decreasing life expectancy does not necessarily increase the amount of pension income, and increasing life expectancy does not necessarily decrease it.

Table 2: Pension liability projections for 21 years of service under different life expectancy scenarios (5% rate of return, 10 vs 15 years)

Length of service	Annual Salary projection	Accrued annual retirement benefits	Rate of returns, Life expectancy (5%, 15 years)				Rate of returns, Life expectancy (5%, 10 years)			
			Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**	Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**
1	1,511,608	83,138	807,461	251,770	251,770	668,021	611,906	190,795	190,795	506,237
2	1,587,188	174,591	1,695,668	560,440	308,670	1,416,205	1,285,003	424,710	233,915	1,073,221
3	1,666,548	274,980	2,670,678	935,655	375,215	2,251,766	2,023,879	709,054	284,343	1,706,422
4	1,749,875	384,973	3,738,949	1,388,513	452,857	3,182,496	2,833,431	1,052,236	343,182	2,411,743
5	1,837,369	505,276	4,907,371	1,931,768	543,256	4,216,808	3,718,879	1,463,923	411,687	3,195,560
6	1,929,237	636,648	6,183,287	2,580,070	648,301	5,363,779	4,685,787	1,955,215	491,292	4,064,752
7	2,025,699	779,894	7,574,526	3,350,220	770,151	6,633,207	5,740,089	2,538,847	583,632	5,026,743
8	2,126,984	935,873	9,089,432	4,261,480	911,260	8,035,657	6,888,107	3,229,413	690,566	6,089,540
9	2,233,333	1,105,500	10,736,891	5,335,906	1,074,426	9,582,521	8,136,576	4,043,629	814,216	7,261,777
10	2,345,000	1,289,750	12,526,373	6,598,737	1,262,831	11,286,080	9,492,672	5,000,621	956,992	8,552,759
11	2,462,250	1,489,661	14,467,961	8,078,834	1,480,097	13,159,569	10,964,036	6,122,261	1,121,639	9,972,518
12	2,585,363	1,706,339	16,572,392	9,809,173	1,730,339	15,217,247	12,558,805	7,433,538	1,311,277	11,531,857
13	2,714,631	1,940,961	18,851,096	11,827,411	2,018,237	17,474,472	14,285,641	8,962,988	1,529,450	13,242,415
14	2,850,362	2,194,779	21,316,239	14,176,516	2,349,106	19,947,782	16,153,763	10,743,175	1,780,187	15,116,726
15	2,992,880	2,469,126	23,980,769	16,905,496	2,728,979	22,654,981	18,172,984	12,811,237	2,068,061	17,168,282
16	3,142,524	2,765,421	26,858,461	20,070,204	3,164,709	25,615,232	20,353,742	15,209,500	2,398,263	19,411,604
17	3,299,650	3,085,173	29,963,970	23,734,271	3,664,067	28,849,155	22,707,143	17,986,184	2,776,684	21,862,320
18	3,464,633	3,429,987	33,312,885	27,970,140	4,235,869	32,378,934	25,245,001	21,196,189	3,210,005	24,537,239
19	3,637,865	3,801,569	36,921,781	32,860,253	4,890,113	36,228,429	27,979,876	24,901,990	3,705,800	27,454,444
20	3,819,758	4,201,734	40,808,284	38,498,381	5,638,128	40,423,300	30,925,126	29,174,647	4,272,657	30,633,379
21	4,010,746	4,632,411	44,991,133	44,991,133	6,492,752	44,991,133	34,094,951	34,094,951	4,920,304	34,094,951

Source: Authors' computation

ISSN:2354-3817 (Print) 2354-4066 (Online)
Nigerian Actuarial Journal, Vol. 2, No. 1, PP. 17-32 April, 2025

Table 3: Pension liability projections for 20 years of service under different life expectancy scenarios (5% rate of return, 10 vs 15 years)

Length of service	Annual Salary projection	Accrued annual retirement benefits	Rate of returns, Life expectancy (5%, 15 years)				Rate of returns, Life expectancy (5%, 10 years)			
			Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**	Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**
1	1,511,608	83,138	807,461	237,519	237,519	661,719	611,906	179,995	179,995	501,461
2	1,587,188	174,591	1,695,668	528,717	291,198	1,402,845	1,285,003	400,670	220,674	1,063,097
3	1,666,548	274,980	2,670,678	882,694	353,976	2,230,523	2,023,879	668,919	268,249	1,690,324
4	1,749,875	384,973	3,738,949	1,309,918	427,224	3,152,473	2,833,431	992,675	323,757	2,388,991
5	1,837,369	505,276	4,907,371	1,822,423	512,505	4,177,026	3,718,879	1,381,059	388,384	3,165,413
6	1,929,237	636,648	6,183,287	2,434,028	611,605	5,313,178	4,685,787	1,844,543	463,483	4,026,405
7	2,025,699	779,894	7,574,526	3,160,585	726,557	6,570,630	5,740,089	2,395,139	550,596	4,979,321
8	2,126,984	935,873	9,089,432	4,020,264	859,679	7,959,849	6,888,107	3,046,616	651,478	6,032,092
9	2,233,333	1,105,500	10,736,891	5,033,874	1,013,609	9,492,119	8,136,576	3,814,744	768,128	7,193,270
10	2,345,000	1,289,750	12,526,373	6,225,224	1,191,350	11,179,607	9,492,672	4,717,567	902,823	8,472,073
11	2,462,250	1,489,661	14,467,961	7,621,541	1,396,318	13,035,422	10,964,036	5,775,718	1,058,150	9,878,437
12	2,585,363	1,706,339	16,572,392	9,253,937	1,632,396	15,073,688	12,558,805	7,012,771	1,237,054	11,423,066
13	2,714,631	1,940,961	18,851,096	11,157,934	1,903,998	17,309,619	14,285,641	8,455,649	1,442,878	13,117,487
14	2,850,362	2,194,779	21,316,239	13,374,072	2,216,137	19,759,595	16,153,763	10,135,071	1,679,422	14,974,116
15	2,992,880	2,469,126	23,980,769	15,948,581	2,574,509	22,441,255	18,172,984	12,086,072	1,951,001	17,006,317
16	3,142,524	2,765,421	26,858,461	18,934,155	2,985,574	25,373,579	20,353,742	14,348,585	2,262,513	19,228,476
17	3,299,650	3,085,173	29,963,970	22,390,822	3,456,667	28,576,993	22,707,143	16,968,098	2,619,514	21,656,071
18	3,464,633	3,429,987	33,312,885	26,386,925	3,996,103	32,073,472	25,245,001	19,996,405	3,028,307	24,305,755
19	3,637,865	3,801,569	36,921,781	31,000,239	4,613,314	35,886,652	27,979,876	23,492,443	3,496,038	27,195,439
20	3,819,758	4,201,734	40,808,284	36,319,227	5,318,988	40,041,948	30,925,126	27,523,252	4,030,809	30,344,385
21	4,010,746	4,632,411	44,991,133	42,444,465	6,125,238	44,566,688	34,094,951	32,165,048	4,641,796	33,773,301
22	4,211,283	5,095,653	49,490,246	49,490,246	7,045,781	49,490,246	37,504,446	37,504,446	5,339,398	37,504,446

Source: Authors' computation

ISSN:2354-3817 (Print) 2354-4066 (Online)
Nigerian Actuarial Journal, Vol. 2, No. 1, PP. 17-32 April, 2025

Table 4: Pension liability projections for 23 years of service under different life expectancy scenarios (5% rate of return, 10 vs 15 years)

Length of service	Annual Salary projection	Accrued annual retirement benefits	Annual Salary projection				Accrued annual retirement benefits			
			Total value of benefits at retirement	Present value of accrued benefits to be received at retirement				Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	
1	1,439,627	83,138	807,461	224,075	224,075	655,477	611,906	169,807	169,807	496,730
2	1,511,608	174,591	1,695,668	498,790	274,715	1,389,610	1,285,003	377,991	208,183	1,053,067
3	1,587,188	274,980	2,670,678	832,730	333,940	2,209,481	2,023,879	631,055	253,065	1,674,377
4	1,666,548	384,973	3,738,949	1,235,771	403,041	3,122,733	2,833,431	936,486	305,431	2,366,453
5	1,749,875	505,276	4,907,371	1,719,267	483,496	4,137,621	3,718,879	1,302,886	366,400	3,135,551
6	1,837,369	636,648	6,183,287	2,296,253	576,986	5,263,053	4,685,787	1,740,135	437,249	3,988,420
7	1,929,237	779,894	7,574,526	2,981,684	685,431	6,508,643	5,740,089	2,259,565	519,430	4,932,346
8	2,025,699	935,873	9,089,432	3,792,702	811,018	7,884,756	6,888,107	2,874,166	614,602	5,975,185
9	2,126,984	1,105,500	10,736,891	4,748,937	956,235	9,402,571	8,136,576	3,598,816	724,649	7,125,409
10	2,233,333	1,289,750	12,526,373	5,872,853	1,123,915	11,074,139	9,492,672	4,450,535	851,720	8,392,148
11	2,345,000	1,489,661	14,467,961	7,190,133	1,317,281	12,912,446	10,964,036	5,448,790	998,255	9,785,244
12	2,462,250	1,706,339	16,572,392	8,730,129	1,539,996	14,931,484	12,558,805	6,615,822	1,167,032	11,315,301
13	2,585,363	1,940,961	18,851,096	10,526,353	1,796,224	17,146,320	14,285,641	7,977,027	1,361,205	12,993,737
14	2,714,631	2,194,779	21,316,239	12,617,049	2,090,696	19,573,184	16,153,763	9,561,388	1,584,360	14,832,851
15	2,850,362	2,469,126	23,980,769	15,045,831	2,428,782	22,229,545	18,172,984	11,401,955	1,840,567	16,845,880
16	2,992,880	2,765,421	26,858,461	17,862,410	2,816,580	25,134,205	20,353,742	13,536,401	2,134,446	19,047,075
17	3,142,524	3,085,173	29,963,970	21,123,417	3,261,006	28,307,399	22,707,143	16,007,640	2,471,239	21,451,769
18	3,299,650	3,429,987	33,312,885	24,893,325	3,769,909	31,770,892	25,245,001	18,864,533	2,856,893	24,076,456
19	3,464,633	3,801,569	36,921,781	29,245,508	4,352,183	35,548,098	27,979,876	22,162,682	3,298,149	26,938,879
20	3,637,865	4,201,734	40,808,284	34,263,422	5,017,914	39,664,194	30,925,126	25,965,332	3,802,650	30,058,117
21	3,819,758	4,632,411	44,991,133	40,041,948	5,778,526	44,146,248	34,094,951	30,344,385	4,379,053	33,454,685
22	4,010,746	5,095,653	49,490,246	46,688,911	6,646,963	49,023,357	37,504,446	35,381,553	5,037,168	37,150,631
23	4,211,283	5,593,637	54,326,793	54,326,793	7,637,881	54,326,793	41,169,653	41,169,653	5,788,100	41,169,653

Source: Authors' computation

ISSN:2354-3817 (Print) 2354-4066 (Online)
Nigerian Actuarial Journal, Vol. 2, No. 1, PP. 17-32 April, 2025

Table 5: Pension liability projections for 24 years of service under different life expectancy scenarios (5% rate of return, 10 vs 15 years)

Length of service	Annual Salary projection	Accrued annual retirement benefits	Rate of returns, Life expectancy (5%, 15 years)				Rate of returns, Life expectancy (5%, 10 years)			
			Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**	Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**
1	1,511,608	83,138	807,461	211,391	211,391	649,293	611,906	160,195	160,195	492,044
2	1,587,188	174,591	1,695,668	470,557	259,166	1,376,501	1,285,003	356,595	196,399	1,043,133
3	1,666,548	274,980	2,670,678	785,594	315,038	2,188,636	2,023,879	595,335	238,740	1,658,581
4	1,749,875	384,973	3,738,949	1,165,822	380,228	3,093,273	2,833,431	883,477	288,142	2,344,128
5	1,837,369	505,276	4,907,371	1,621,950	456,128	4,098,586	3,718,879	1,229,138	345,660	3,105,970
6	1,929,237	636,648	6,183,287	2,166,276	544,326	5,213,402	4,685,787	1,641,636	412,499	3,950,794
7	2,025,699	779,894	7,574,526	2,812,910	646,633	6,447,240	5,740,089	2,131,665	490,028	4,885,815
8	2,126,984	935,873	9,089,432	3,578,021	765,111	7,810,371	6,888,107	2,711,478	579,813	5,918,816
9	2,233,333	1,105,500	10,736,891	4,480,130	902,109	9,313,868	8,136,576	3,395,109	683,631	7,058,188
10	2,345,000	1,289,750	12,526,373	5,540,427	1,060,297	10,969,666	9,492,672	4,198,618	803,509	8,312,977
11	2,462,250	1,489,661	14,467,961	6,783,145	1,242,718	12,790,631	10,964,036	5,140,368	941,750	9,692,931
12	2,585,363	1,706,339	16,572,392	8,235,971	1,452,826	14,790,620	12,558,805	6,241,342	1,100,973	11,208,553
13	2,714,631	1,940,961	18,851,096	9,930,522	1,694,551	16,984,563	14,285,641	7,525,498	1,284,156	12,871,155
14	2,850,362	2,194,779	21,316,239	11,902,876	1,972,354	19,388,531	16,153,763	9,020,177	1,494,680	14,692,918
15	2,992,880	2,469,126	23,980,769	14,194,180	2,291,304	22,019,832	18,172,984	10,756,561	1,736,384	16,686,957
16	3,142,524	2,765,421	26,858,461	16,851,331	2,657,151	24,897,090	20,353,742	12,770,190	2,013,628	18,867,386
17	3,299,650	3,085,173	29,963,970	19,927,752	3,076,421	28,040,348	22,707,143	15,101,547	2,331,358	21,249,394
18	3,464,633	3,429,987	33,312,885	23,484,269	3,556,518	31,471,167	25,245,001	17,796,729	2,695,182	23,849,319
19	3,637,865	3,801,569	36,921,781	27,590,102	4,105,833	35,212,739	27,979,876	20,908,191	3,111,461	26,684,738
20	3,819,758	4,201,734	40,808,284	32,323,983	4,733,881	39,290,003	30,925,126	24,495,596	3,587,405	29,774,550
21	4,010,746	4,632,411	44,991,133	37,775,423	5,451,440	43,729,774	34,094,951	28,626,778	4,131,182	33,139,074
22	4,211,283	5,095,653	49,490,246	44,046,143	6,270,720	48,560,873	37,504,446	33,378,824	4,752,045	36,800,153
23	4,421,847	5,593,637	54,326,793	51,251,691	7,205,549	53,814,276	41,169,653	38,839,296	5,460,472	40,781,261
24	4,642,940	6,128,680	59,523,269	59,523,269	8,271,577	59,523,269	45,107,620	45,107,620	6,268,325	45,107,620

Source: Authors' computation

ISSN:2354-3817 (Print) 2354-4066 (Online)
Nigerian Actuarial Journal, Vol. 2, No. 1, PP. 17-32 April, 2025

Table 6: Pension liability projections for 25 years of service under different life expectancy scenarios (5% rate of return, 10 vs 15 years)

Length of service	Annual Salary projection	Accrued annual retirement benefits	Rate of returns, Life expectancy (5%, 15 years)				Rate of returns, Life expectancy (5%, 10 years)			
			Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**	Total value of benefits at retirement	Present value of accrued benefits to be received at retirement	normal cost*	**Pension liability**
1	1,511,608	83,138	807,461	224,075	224,075	655,477	611,906	169,807	169,807	496,730
2	1,587,188	174,591	1,695,668	498,790	274,715	1,389,610	1,285,003	377,991	208,183	1,053,067
3	1,666,548	274,980	2,670,678	832,730	333,940	2,209,481	2,023,879	631,055	253,065	1,674,377
4	1,749,875	384,973	3,738,949	1,235,771	403,041	3,122,733	2,833,431	936,486	305,431	2,366,453
5	1,837,369	505,276	4,907,371	1,719,267	483,496	4,137,621	3,718,879	1,302,886	366,400	3,135,551
6	1,929,237	636,648	6,183,287	2,296,253	576,986	5,263,053	4,685,787	1,740,135	437,249	3,988,420
7	2,025,699	779,894	7,574,526	2,981,684	685,431	6,508,643	5,740,089	2,259,565	519,430	4,932,346
8	2,126,984	935,873	9,089,432	3,792,702	811,018	7,884,756	6,888,107	2,874,166	614,602	5,975,185
9	2,233,333	1,105,500	10,736,891	4,748,937	956,235	9,402,571	8,136,576	3,598,816	724,649	7,125,409
10	2,345,000	1,289,750	12,526,373	5,872,853	1,123,915	11,074,139	9,492,672	4,450,535	851,720	8,392,148
11	2,462,250	1,489,661	14,467,961	7,190,133	1,317,281	12,912,446	10,964,036	5,448,790	998,255	9,785,244
12	2,585,363	1,706,339	16,572,392	8,730,129	1,539,996	14,931,484	12,558,805	6,615,822	1,167,032	11,315,301
13	2,714,631	1,940,961	18,851,096	10,526,353	1,796,224	17,146,320	14,285,641	7,977,027	1,361,205	12,993,737
14	2,850,362	2,194,779	21,316,239	12,617,049	2,090,696	19,573,184	16,153,763	9,561,388	1,584,360	14,832,851
15	2,992,880	2,469,126	23,980,769	15,045,831	2,428,782	22,229,545	18,172,984	11,401,955	1,840,567	16,845,880
16	3,142,524	2,765,421	26,858,461	17,862,410	2,816,580	25,134,205	20,353,742	13,536,401	2,134,446	19,047,075
17	3,299,650	3,085,173	29,963,970	21,123,417	3,261,006	28,307,399	22,707,143	16,007,640	2,471,239	21,451,769
18	3,464,633	3,429,987	33,312,885	24,893,325	3,769,909	31,770,892	25,245,001	18,864,533	2,856,893	24,076,456
19	3,637,865	3,801,569	36,921,781	29,245,508	4,352,183	35,548,098	27,979,876	22,162,682	3,298,149	26,938,879
20	3,819,758	4,201,734	40,808,284	34,263,422	5,017,914	39,664,194	30,925,126	25,965,332	3,802,650	30,058,117
21	4,010,746	4,632,411	44,991,133	40,041,948	5,778,526	44,146,248	34,094,951	30,344,385	4,379,053	33,454,685
22	4,211,283	5,095,653	49,490,246	46,688,911	6,646,963	49,023,357	37,504,446	35,381,553	5,037,168	37,150,631
23	4,421,847	5,593,637	54,326,793	54,326,793	7,637,881	54,326,793	41,169,653	41,169,653	5,788,100	41,169,653
24	4,642,940	6,128,680	59,523,269	59,523,269	8,271,577	59,523,269	45,107,620	45,107,620	6,268,325	45,107,620
25	4,875,087	6,703,244	65,103,575	65,103,575	8,949,548	65,103,575	49,336,460	49,336,460	6,782,101	49,336,460

Source: Authors' computation

ISSN:2354-3817 (Print) 2354-4066 (Online)
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DISCUSSION

The findings from this study have significant implications for individuals, employers, and policymakers. In reality, employees who dedicate more years of service to their organization are likely to receive higher benefits at retirement, which is a fair reflection of their commitment and loyalty. For instance, an employee who retires after 25 years of service with a life expectancy of 15 years can expect to receive approximately N65,103,575 as their total value of benefits at retirement. This amount can provide a comfortable retirement for the employee and their dependents.

However, the results also highlight the importance of life expectancy in determining the total value of benefits at retirement. Employees with higher life expectancy at retirement will receive more benefits, which can be a challenge for employers who need to fund these benefits. This is particularly relevant in today's world, where people are living longer due to advances in medical technology and improvements in healthcare. As a result, employers may need to reassess their pension plans and consider increasing contributions to ensure that they can meet their future liabilities.

Furthermore, the study's findings have implications for retirement planning. Employees who retire earlier may receive lower benefits, which can impact their standard of living in retirement. For example, an employee who retires after 15 years of service with a life expectancy of 15 years will receive significantly lower benefits (N23,980,769) compared to an employee who retires after 25 years of service (N65,103,575). This highlights the need for employees to plan carefully for their retirement and consider factors such as life expectancy, years of service, and pension scheme rules when making decisions about their retirement.

The contrast between the theoretical expectation and the actual results of the study also has important implications for policymakers. While it may be assumed that increasing life expectancy should lead to lower retirement income, the study's findings suggest that this is not necessarily the case. Instead, increasing life expectancy can lead to higher pension liabilities for employers, which can have significant implications for the sustainability of pension schemes. This highlights the need for policymakers to consider the complex relationship between life expectancy, pension income, and pension scheme design when developing policies to support retirement income security.

5. CONCLUSION AND CONTRIBUTION TO KNOWLEDGE

This study makes a significant contribution to the existing literature by developing models to predict the total value of benefits at retirement, total value of benefits with salary adjustment to future increment, and pension liability. Unlike previous approaches that relied on software without transparent procedural validation, our study provides a clear and theoretical foundation for estimating these critical retirement variables. The resulting models offer a valuable tool for non-actuarial experts, such as human resource managers and pension administrators, to assess the pension liability of their current and retiring employees without requiring specialized actuarial expertise. By providing a free and accessible means of estimating retirement benefits and liabilities, this study has the potential to enhance retirement planning, pension management, and overall financial sustainability for individuals and organizations alike.

In conclusion, the results of this study have significant implications for individuals, employers, and policymakers. They highlight the importance of considering factors such as life expectancy, years of service, and pension scheme rules when planning for retirement. Employers may need to reassess their pension plans to ensure that they can meet their future liabilities, and policymakers may need to consider the complex relationship between life expectancy, pension income, and pension scheme design when developing policies to support retirement income security. Ultimately, the study's findings can inform strategies to promote retirement income security and support individuals in achieving a comfortable and sustainable retirement.

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