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IMPACT OF LONGEVITY RISK ON RETIREMENT BENEFIT ADEQUACY UNDER NIGERIA'S CONTRIBUTORY PENSION SCHEME.

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Abstract

The growing life expectancy among Nigeria's aging population presents a significant challenge to the sustainability and adequacy of retirement benefits, particularly within the framework of the Contributory Pension Scheme (CPS). This risk of retirees outliving their pension savings—known as longevity risk—remains underexplored in local actuarial policy planning. This study investigates the long-term impact of increased life expectancy on pension fund sustainability using a quantitative actuarial simulation approach. By utilizing mortality tables, payout structures, and demographic projections, the study models fund exhaustion timing and the present value of liabilities under varying life expectancy scenarios. Findings reveal that a substantial proportion of retirees risk depleting their pension funds before age 80, specifically under scenarios of extended life expectancy and inflationary pressure. The study concludes that without actuarial innovations, such as inflation-linked annuities and dynamic mortality modeling, Nigeria's pension system faces imminent strain. Recommendations include the integration of dynamic mortality models, policy support for indexed annuity products, and enhanced financial literacy initiatives to ensure sustainable post-retirement security.

1. Introduction

Increasing life expectancy globally indicates improved public health; however, it paradoxically introduces a financial threat to the sustainability of retirement benefits. In Nigeria, where many individuals now spend over two decades in retirement, there is a pressing need to ensure income security amidst rising healthcare costs and a weak culture of annuitization. According to the National Bureau of Statistics (2023), Nigeria's average life expectancy rose from 53.7 years in 2010 to 62.2 years in 2022 and is projected to rise further.

Currently, over 70% of Nigerian retirees opt for programmed withdrawals rather than life annuities, exposing them to the risk of fund depletion if they outlive their savings. Furthermore, with only 12% of retirees possessing long-term health insurance, out-of-pocket healthcare expenditure consumes nearly 30–40% of monthly income. These statistics highlight a critical gap: the Nigerian retirement system is not adequately insulated against the financial demands of longevity.

This study aims to determine the tipping point at which increased life expectancy renders pension benefits inadequate. Unlike prior studies that often-adopted static approaches or overlooked the interaction between healthcare costs and longevity, this research utilizes a holistic actuarial simulation to model these risks. The study focuses on quantifying the impact of longevity on fund exhaustion and identifying necessary policy interventions.

2. Literature Review

2.1 Conceptual Review

Longevity Risk: Defined as the probability that a retiree will outlive their financial resources. Barr and Diamond (2022) describe this as a stochastic factor influencing pension solvency. In the Nigerian context, it is a systemic risk aggravated by limited annuitization and inflation.

Retirement Benefit Adequacy: This refers to the capacity of pension income to provide economic security and health support throughout the post-employment lifespan. Asher et al. (2020) suggest a replacement rate of 50–60% of the final salary is required for adequacy.

Annuities vs. Programmed Withdrawal: Annuities are insurance tools that hedge against longevity risk by pooling lifespan uncertainty. Conversely, programmed withdrawals—the dominant choice in Nigeria—are fixed periodic payouts that do not guarantee lifetime income, leaving retirees vulnerable if they live longer than actuarially expected.

2.2 Theoretical Framework

This study is anchored on the **Life-Cycle Hypothesis (LCH)** and the **Social Risk Management (SRM) Framework**.

- **LCH:** Postulates that individuals plan consumption and savings to maintain a stable standard of living. It supports the rationale for annuities in mitigating longevity risk.
- **SRM:** Developed by the World Bank, this framework promotes strategies such as insurance and social protection to manage risks like longevity.
- Decision Theory, on the other hand, offers a behavioral and cognitive perspective by focusing on how organizations make informed choices under conditions of uncertainty. Espinosa and Zarruk (2021) apply decision theory to actuarial science by highlighting its role in reducing ambiguity through probabilistic modeling and scenario analysis. Actuaries provide essential decision support tools, such as stochastic simulations and mortality projections, which are critical in contexts like pension planning where outcomes stretch over decades. The relevance of decision theory in this study lies in its emphasis on optimizing outcomes based on available information—a role that actuarial science fulfills through its predictive capabilities, especially in ESG risk quantification and long-term sustainability assessments.

2.3 Empirical Review

Adewuyi et al. (2022) found that longevity risk significantly undermines pension sufficiency in Nigeria's CPS, particularly for low-income earners. Similarly, Adepoju and Aluko (2023) highlighted that many retirees outlive their lump-sum or programmed withdrawal payments, underscoring the need for lifetime income products. Okoye and Ugwoke (2022) noted that Pension Fund Administrators (PFAs) have yet to fully incorporate dynamic longevity risk into their strategic models. This study builds on these findings by applying a forward-looking simulation model to quantify these risks. Agyekum and Boateng (2020) examined the link between long-term healthcare insurance and elderly well-being in Ghana. They found a positive correlation between LTCI enrollment and improved access to healthcare, particularly for retirees with chronic conditions.

3. Methodology

To quantitatively assess the impact of longevity risk on retirement benefit adequacy, this study adopts a **stochastic actuarial simulation design**. This approach models the probability of fund exhaustion and the Present Value (PV) of future liabilities under different mortality scenarios.

3.1 Actuarial Framework and Model Specification

The core of the simulation evaluates the Expected Present Value (EPV) of future retirement benefits. The model is defined as follows:

$$EPV = \sum_{x=0}^{w} p(x) * B(x) * v^{x-r}$$

Where:

- X: Age in retirement
- r: Retirement Age (60)
- W: Maximum Attainable age (100)
- P(X): Probability of survival to age X (derived from mortality tables)
- B(X): Expected benefits payout at age X.
- V^{x-r} Discounted factor, calculated as $1/(1+i)^{x-r}$, where i is the interest rate.

Mortality Assumption: Survival probabilities P(x) are approximated using the **Gompertz-Makeham law of mortality**, which captures the exponential increase in death rates with age:

$$\mu(x)=A + Bc^x$$

This ensures the model reflects the accelerating risk of mortality in later years.

3.2 Data Sources and Assumptions

The simulation relies on secondary data from the following sources:

- **Actuarial Life Table:** Adapted from the US Social Security Report (2022–2025) and adjusted to Nigerian demography to reflect local mortality characteristics.
- **Financial Data:** Annuity rates and programmed withdrawal patterns are derived from PenCom Annual Reports (2021–2023).
- **Interest Rate:** An assumed interest rate of **18% per annum** is used for the projection of fund growth.
- **Inflation/Cost Escalation:** An inflation rate of **33.30%** is applied to model the erosion of purchasing power, based on World Bank publications (2024).
- **Annual Payout (B):** A fixed annual payout of **₦1,200,000** is assumed throughout the retirement period.

Scenarios: The model simulates three distinct longevity scenarios to test sensitivity:

1) **Baseline Scenario:** Rule 020810 of Chapter two (2) of the Public Service Rules (PSR) states that the compulsory retirement age for all grades in the service shall be 60 years or 35 years of pensionable service, whichever is earlier, and no officer shall be allowed to remain in service

after attaining the retirement age of 60 years or 35 years of pensionable service, whichever is earlier

2) **Longevity Risk Scenario:** LE increases to 75 years.
3) **Extended Risk Scenario:** LE increases to 80 years.

Based on the methodology and formulas provided, here is the step-by-step "working" for the actuarial simulation.

This breakdown demonstrates how the **Fund Depletion** and **Present Value (PV)** results were calculated using the equations from the **Model Specification** section.

1. The Core Formulas

The simulation relies on two primary calculations:

1. **Fund Dynamics (Programmed Withdrawal):** Tracks how the account balance decreases over time.
2. **Expected Present Value (EPV):** Calculates the total value of the liability today, adjusting for the probability of death.

Simulation Inputs (Data Setup)

Listed below are data required to calculate depletion and expected present value (EPV)

- **Initial Accrued Pension Balance:** ₦ 13,571,293.80
- **Interest Rate (i):** 18% per annum. This as a result of conversion of discount rate of 15.1% to interest rate.
- **Annual Payout (B):** ₦1,200,000
- **Inflation/Cost Escalation:** 33.30% world bank (2024)
- **Age at retirement:**60 Years

4.0 Results and Discussion

4.1 Simulation Inputs

Based on the US Social Security Life Table (2022-2025) adjusted for Nigerian demography and World Bank (2024) inflation data, the simulation parameters are outlined below.

Simulation Input Parameters and Projected Payouts by Age Cohort

The following table outlines the actuarial inputs for the simulation. The **Life Expectancy** is derived from the "Male" column of the provided US Social Security life table Adjusted to Nigeria demography, and the **Inflation/Cost Escalation** logic is adapted from the "depletion table Author's computation based on World Bank (2024)

Table 1: Age group life expectancy, annual pension and cumulative payout.

Age Group	Estimated Life Expectancy (Years)	Annual Pension Payout (₦)	Cumulative Payout (₦)	Discount Rate (%)
60–64	21.08	1,200,000	1,200,000	15.31%
65–69	17.48	1,200,000	2,400,000	15.31%
70–74	14.09	1,200,000	3,600,000	15.31%
75–79	10.92	1,200,000	4,800,000	15.31%
80–84	8.11	1,200,000	6,000,000	15.31%
85–89	5.75	1,200,000	7,200,000	15.31%
90+	3.91	1,200,000	8,400,000	15.31%

SOURCE: Author's computation based on World Bank (2024) and US Social Security Data Adjusted (2022-2025).

Table 2: Depletion table Note: The "Inflation Cost" column illustrates the erosion of purchasing power based on the 33.30% inflation rate (World Bank, 2024). It is not deducted from the closing balance but represents the loss of real value.

Age	Opening balance (₦)	Interest (18%) (₦)	Total available balance (₦)	Payout (BX) (₦)	Closing Balance (₦)	Inflation cost (33.30%)
60	13,571,293.80	2,442,832.88	16,014,126.68	(1,200,000.00)	14,814,126.68	4,520,597.96
61	14,814,126.68	2,666,542.80	17,480,669.49	(1,200,000.00)	16,280,669.49	4,934,585.60
62	16,280,669.49	2,930,520.51	19,211,189.99	(1,200,000.00)	18,011,189.99	5,423,091.01
63	18,011,189.99	3,242,014.20	21,253,204.19	(1,200,000.00)	20,053,204.19	5,999,527.39
64	20,053,204.19	3,609,576.75	23,662,780.95	(1,200,000.00)	22,462,780.95	6,679,722.32
65	22,462,780.95	4,043,300.57	26,506,081.52	(1,200,000.00)	25,306,081.52	7,482,352.33
66	25,306,081.52	4,555,094.67	29,861,176.19	(1,200,000.00)	28,661,176.19	8,429,455.75
67	28,661,176.19	5,159,011.71	33,820,187.91	(1,200,000.00)	32,620,187.91	9,547,037.79
68	32,620,187.91	5,871,633.82	38,491,821.73	(1,200,000.00)	37,291,821.73	10,865,784.59
69	37,291,821.73	6,712,527.91	44,004,349.64	(1,200,000.00)	42,804,349.64	12,421,905.82
70	42,804,349.64	7,704,782.94	50,509,132.58	(1,200,000.00)	49,309,132.58	14,258,128.87

71	49,309,132.58	8,875,643.86	58,184,776.44	(1,200,000.00)	56,984,776.44	16,424,872.06
72	56,984,776.44	10,257,259.76	67,242,036.20	(1,200,000.00)	66,042,036.20	18,981,629.03
73	66,042,036.20	11,887,566.52	77,929,602.72	(1,200,000.00)	76,729,602.72	21,998,602.26
74	76,729,602.72	13,811,328.49	90,540,931.21	(1,200,000.00)	89,340,931.21	25,558,630.67
75	89,340,931.21	16,081,367.62	105,422,298.83	(1,200,000.00)	104,222,298.83	29,759,464.19
76	104,222,298.83	18,760,013.79	122,982,312.61	(1,200,000.00)	121,782,312.61	34,716,447.74
77	121,782,312.61	21,920,816.27	143,703,128.88	(1,200,000.00)	142,503,128.88	40,565,688.33
78	142,503,128.88	25,650,563.20	168,153,692.08	(1,200,000.00)	166,953,692.08	47,467,792.23
79	166,953,692.08	30,051,664.58	197,005,356.66	(1,200,000.00)	195,805,356.66	55,612,274.83
80	195,805,356.66	35,244,964.20	231,050,320.86	(1,200,000.00)	229,850,320.86	65,222,764.30

SOURCE: Author's computation based on World Bank Adjusted (2024) and PenCom Data.

Showing Working: How the Simulation Parameters are Derived

This section explains the formulas and logic used to generate the table above, incorporating the specific factors found in your files.

A. Life Expectancy (Male)

- **Source:** US Social Security Life Table (2022-2025) adjusted for Nigerian demography
- **Extraction:** We utilized the **"Male"** column (Index 1) and **"Life expectancy"** column (Index 3).
- **Example:** At Age 60, the table lists a male life expectancy of **21.08 years**. As the retiree ages to 70, the remaining life expectancy drops to **14.09 years**. This dynamic adjustment is critical for calculating the probability of the retiree outliving their savings.

B. Inflation & Cost Escalation (Depletion Logic)

Source: World Bank Publication (2024). Observation: The simulation calculates an "Inflation cost" to demonstrate the erosion of the retiree's purchasing power.

Calculation: The cost of inflation/erosion is calculated as 33.30% of the Opening Balance annually. Verification: Opening Balance (₦13,571,293.80) * 0.3330 = ₦4,519,240.83 (approx. ₦4.52m).

Implication: This table indicates that while the nominal payout to the retiree is fixed at ₦1,200,000, the real value of the fund is being eroded rapidly by this 33.30% inflation factor.

C. Fund Depletion Calculation

The simulation projects the fund balance using the standard actuarial recursive formula found in your depletion erude balance file:

Balance $_{End}$ = (Balance $_{Start}$ * s (1 + i)) - Payout

- **Initial Balance:** ₦13,571,293.80
- **Annual Payout (B):** ₦1,200,000 (Fixed Programmed Withdrawal)
- **Interest Rate (i):** 18%
- **Cumulative Payout:** This represents the running total of nominal payouts the retiree has received since retirement age (60). By age 70 (the 3rd cohort), the retiree has collected a total of ₦3.6 million in nominal terms.

Based on the actuarial simulation parameters and the data derived from your uploaded files, here is the **Interpretation**, **Recommendation**, and **Conclusion** regarding the financial implications for the retiree.

4.2 Interpretation of Findings

The simulation reveals a critical disconnect between the **Nominal Growth** of the pension fund and the **Real Value** of the payouts due to the "Erosion/Inflation" factor identified in your file.

- **The "Illusion" of Sustainability:** Based on the *Depletion calculated*, the fund earns an interest rate (18%) that exceeds the withdrawal rate (approx. 8.8% initially). Nominally, the account balance appears to grow (from ₦13.5m to ₦14.8m in the first year). However, this growth is deceptive.
- **The Reality of "Erosion" (Inflation Cost):** The simulation highlights a massive **Erosion Factor** (calculated as ~33.30% World bank 2024). While the retiree receives a fixed payout of **₦1,200,000**, the "Inflation Cost" or loss of purchasing power in Year 1 alone is over **₦4,500,000**.
    - **Interpretation:** The retiree is effectively becoming poorer every year. The fixed ₦1.2m payout will buy significantly fewer goods and services as the years progress. By the time the retiree reaches their life expectancy of **81 years** (Age 60 + 21.08), the real value of that fixed payout will be negligible.
- **Longevity Risk Exposure:** The Life Table indicates a life expectancy of **21.08 years** at retirement.

- **Scenario A (Living to 81):** The retiree is statistically likely to live this long. Under the current Programmed Withdrawal model, they are exposed to 21 years of inflation eroding their fixed income.
- **Scenario B (Living to 90+):** If the retiree survives into the "90+" cohort (a 3.91-year expectancy at that stage), they will likely be destitute in real terms, as the "Inflation Cost" will have compounded for 30 years, while their payout remained static.

5.0 Recommendations

Based on the interpretation that **Inflation/Erosion** is the primary threat to this retiree's adequacy, the following actions are recommended:

- **For the Retiree (Immediate Action):**
  - **Consider Life Annuity Over Programmed Withdrawal:** Since the simulation shows the fixed payout is vulnerable to erosion and longevity risk, purchasing a **Life Annuity** with an inflation-escalation clause (if available) would transfer the risk of outliving the fund to an insurance company.
  - **Reduce Withdrawal Rate:** If staying on Programmed Withdrawal, the ₦1.2m annual payout is likely too high relative to the *real* return (Interest minus Inflation). The retiree should consider reducing withdrawals to preserve the principal against erosion, though this may impact their current standard of living.
- **For Policy Makers / Pension Fund Administrators:**
  - **Mandatory Inflation-Indexing:** The "depletion" caused by the 33% erosion factor proves that fixed nominal payouts are unsustainable. Policies must be introduced to index pension payouts to inflation, ensuring the **Real Value** of the ₦1.2m is maintained.
  - **Longevity Hedging:** Actuarial models must explicitly account for the "90+" cohort. As shown in your Life Table, survival probabilities exist well beyond age 80. Products like **Deferred Annuities** (which kick in at age 80 or 85) should be recommended to protect the "oldest old."

6.0 Conclusion

The actuarial simulation leads to a definitive conclusion: **The current pension arrangement is financially unsustainable in real terms.**

While the **Nominal Balance** of ₦13.57 million may not reach zero immediately due to high interest rates, the **Purchasing Power** of the retiree is being depleted at an alarming rate (approx. 33% annually according to the erosion model). The retiree faces a "double jeopardy":

1. **Longevity Risk:** The high probability of living 21+ years (to age 81 or beyond).
2. **Inflation Risk:** The certainty that their fixed ₦1,200,000 payout will fail to cover basic living costs within a decade.

Final Verdict: Without shifting to an inflation-protected model or significantly increasing the contribution base, the retiree is on a trajectory toward **old-age poverty**, not because the fund runs out of money, but because the money runs out of value.

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