



Impact of Macroeconomic Volatility on the Real Returns of Pension Fund Investments in Nigeria: A Vector Autoregression Analysis

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Abstract

Theories suggest that inflation and macroeconomic volatility diminish real pension returns in Nigeria; however, quantitative empirical studies to substantiate these theories have been limited, resulting in a knowledge gap. In this context, the study examined the dynamic influence of macroeconomic volatility on the real returns of pension funds in Nigeria from the first quarter of 2007 to the fourth quarter of 2024. Based on the Fisher Effect Hypothesis and Modern Portfolio Theory (MPT), the research utilised a Vector Error Correction Model (VECM) and supplementary time-series diagnostics to analyse both short- and long-term relationships among real pension fund returns (RRPF), inflation (INF), inflation volatility (INFVOL), and real GDP growth (RGDPG). The Granger causality analysis indicates that both inflation (INF; $p = 0.000$) and inflation volatility (INFVOL; $p = 0.003$) significantly influence variations in real pension returns (RRPF), whereas GDP growth does not exert a significant effect. Impulse response analysis shows that RRPF keeps reacting negatively to shocks in INF and INFVOL. The 12-quarter Forecast Error Variance Decomposition (FEVD) shows that 51%, 10%, 19% and 21% of the changes in RRPF are due to its own shocks, INF, INFVOL, and RGDPG respectively. These findings validate a partial Fisher effect and underscore inflation uncertainty as the primary non-diversifiable risk to pension sustainability in Nigeria. The study concludes that inflation volatility, (not inflation itself) is the primary systematic risk degrading real pension returns in Nigeria. Recommendations include coherent inflation management, predictable macroeconomic policy, and strategic portfolio diversification in line with global best practices.

Keywords: Pension Funds, Macroeconomic Volatility, Real Returns, Inflation, Vector Autoregression (VAR).

1. Introduction

High macroeconomic volatility poses a significant threat to the long-term viability of national pension systems in Nigeria. The core challenge lies in the relationship between macroeconomic instability and the real return on pension fund investments (Madukwe and Okeke, 2022). The real rate of return is the annual percentage of profit earned on an investment, adjusted for inflation (Finnish Centre for Pensions, 2024). It reflects the actual increase in an investor's purchasing power. For a retiree, the nominal growth of their pension pot is meaningless if its real value has been eroded.

Key macroeconomic volatility factors in an emerging economy like Nigeria include high and unpredictable inflation, severe currency volatility, and inconsistent economic growth (Ekpeyong, 2023; Oyadeyi, 2024). These factors are intrinsically linked to the real returns of pension funds (Ndume, 2025). Specifically, high inflation directly erodes the value of fixed-income securities, which are the dominant asset class in Nigerian pension portfolios.

The establishment of the Contributory Pension Scheme (CPS) in 2004 was a landmark reform. While successful in terms of asset accumulation with Assets Under Management (AUM) exceeding ₦22.51 trillion by late 2024 (National Pension Commission, 2025), the scheme's ability to deliver positive real returns has been questioned amidst Nigeria's turbulent economic environment. For instance, despite nominal growth, the US dollar value of pension assets

shrank by 56.8% between January 2023 and January 2024 due to currency devaluation (Ecofin Agency, 2024), highlighting extreme vulnerability.

The central problem this research addresses is the widening divergence between the nominal value of Nigerian pension assets and their real, inflation-adjusted value. There is a critical need to understand and quantify the dynamic forces that are systematically eroding the purchasing power of Nigerian retirees' savings. Specifically, the study quantified the short-term impact of inflation shocks on the real returns of pension funds and analysed the dynamic relationship between GDP growth shocks and pension portfolio performance. It is hypothesized in the study that macroeconomic volatility had significant negative effect on the real returns of pension fund investments in Nigeria.

2. Literature Review

2.1 Conceptual Review

2.1.1 Real Return on Pension Funds

The *real return on pension funds (RRPF)* represents the actual growth in the purchasing power of pension assets after adjusting for inflation. It is computed as the nominal rate of return on a fund's investment portfolio minus the prevailing rate of inflation (Finnish Centre for Pensions, 2024). A positive real return indicates that pension assets are appreciating faster than the cost of living, thereby enhancing the long-term welfare of retirees. Conversely, a negative real return implies that inflation is outpacing nominal gains, eroding the real value of savings and reducing the purchasing power of pensioners (Ring, 2010). Hence, maintaining positive real returns is a key measure of the effectiveness and sustainability of any pension system.

2.1.2 Macroeconomic Volatility

Macroeconomic volatility refers to the unpredictable fluctuations and instability observed in key aggregate indicators such as output growth, inflation, fiscal balances, and exchange rates across economic cycles (Fernández-Villaverde and Rubio-Ramírez, 2010). It captures both the frequency and magnitude of deviations from long-term macroeconomic trends and represents an important dimension of systematic risk that cannot be diversified away. Core manifestations of macroeconomic volatility include inflation volatility, exchange rate volatility, and real GDP growth volatility (Wolf, 2005). Persistent macroeconomic volatility creates uncertainty that distorts investment decisions, alters risk–return trade-offs, and undermines the stability of real pension fund returns.

2.2 Theoretical Review

This research is based on the Modern Portfolio (MPT) theory and the Fisher Effect hypothesis. Irving Fisher first proposed the Fisher Effect, which states that nominal interest rates should change based on expected inflation in order to keep the real rate of return the same (Chan-Lau, 2004). Empirical studies examining this relationship in Nigeria yield complex results. For instance, Asemota and Bala (2011) utilised a Kalman filter and cointegration analysis with quarterly CPI and nominal interest rate data from 1961 to 2009. Their findings demonstrate that nominal interest rates do not consistently align one-for-one with inflation over the long term, suggesting a partial Fisher effect within the Nigerian context. Awomuse and Alimi (2012) utilised Johansen cointegration and error correction models on data spanning from 1970 to 2009. They discovered that although nominal interest rates and anticipated inflation generally correlate over the long term, their relationship is not perfectly one-to-one; however, causality flows from inflation to nominal rates, highlighting a robust yet incomplete Fisher effect.

On the other hand, Modern Portfolio Theory (MPT), introduced by Harry Markowitz, defines risk as the difference between portfolio returns and stresses the importance of diversification to lower idiosyncratic risk (Chan-Lau, 2004). It also acknowledges that systematic risk, which is market-wide and cannot be avoided, is always present (Busse, Dacorogna, & Kratz, 2014). In this context, macroeconomic volatility characterized by unpredictable inflation, exchange rate fluctuations, or erratic GDP growth represents a category of systematic risk which cannot be avoided.

2.3 Empirical Review

The study reviewed scholarly research on impact of macroeconomic variables to identify on pension funds investment returns in Nigeria context. Madukwe and Okeke (2022), in their study titled "Effect of inflation on pension fund investment in Federal Government of Nigeria securities," investigated the relationship between the inflation rate (independent variable) and the nominal value of pension investments in FGN securities (dependent variable). Employing an Ordinary Least Squares (OLS) regression, their findings indicated that the inflation rate had no statistically significant impact on the nominal value of these investments. They concluded that the continuous inflow of monthly contributions was substantial enough to offset any erosive effects on the nominal stock of assets. However, the study's primary limitation is its focus on nominal rather than real values. This perspective masks the erosion of purchasing power, which is the ultimate concern for pensioners. Furthermore, by concentrating on a single asset class (FGN securities), the study provides an incomplete picture of the portfolio-wide impact of inflation.

Similarly focused on nominal performance metrics, Fadun, Oyerinde, and Isimoya (2024) in "The Analysis of Net Asset Value and the Performance of Pension Funds in Nigeria," examined Net Asset Value (NAV) as the independent variable and pension fund performance, measured by profit before tax (PBT), as the dependent variable. In a related study, Oyerinde, Fadun, and Isimoya (2025), titled "Returns on investment and performance of pension fund in Nigeria," explored the link between total investment returns and fund performance (PBT). Both studies utilized correlation analysis and found moderate positive associations, concluding that larger funds and higher returns correlate with better nominal outcomes. The critical shortcoming of these studies is their reliance on nominal performance indicators. They do not account for the impact of macroeconomic factors like inflation, which can render high nominal profits meaningless in real terms, thereby offering an incomplete assessment of the scheme's health. Shifting the focus towards real macroeconomic effects, Sani, Sani, and Hassan (2022) conducted a study titled "Modelling the effect of macro-economic variables on pension contribution in Nigeria." Their study modelled the impact of inflation and the exchange rate (independent variables) on the volume of pension contributions (dependent variable). Using an Autoregressive Distributed Lag (ARDL) model, the research revealed a significant and negative long-run relationship between the inflation rate and pension contributions. The authors concluded that high inflation diminishes the real disposable income of contributors, thereby reducing their capacity to contribute. They recommended that macroeconomic stability is essential for the sustainable growth of pension contributions. While this study valuably addresses real impacts, its scope is limited to the flow of new funds into the pension system. It did not analyse the effect of inflation on the accumulated stock of assets already under management, which is affects a retiree's welfare.

The existing literature on the subject matter in Nigeria, while valuable, presents a fragmented picture. Studies like Madukwe and Okeke (2022), Fadun et al. (2024), and Oyerinde et al. (2025) are critically limited by their focus on nominal metrics, which ignores the corrosive effect of inflation on the purchasing power of pension assets. Conversely, while Sani et al. (2022) advance the discourse by examining real impacts, their analysis is confined to the flow

of new contributions, not the performance of the vast, accumulated portfolio. Consequently, a clear research gap emerges. There is a need for a dynamic, portfolio-wide analysis that prioritises real returns as a measure of success for pension beneficiaries. The literature, in the Nigeria context, has yet to explicitly model and quantify the impact of macroeconomic volatility, the uncertainty and unpredictability of key indicators as a distinct risk factor beyond the absolute level of inflation. This study is therefore designed to fill this critical gap by applying a Vector Autoregression (VAR) model to examine the dynamic, system-wide impact of macroeconomic shocks on the real returns of the Nigerian pension fund portfolio.

3. Methodology

3.1 Estimation Techniques

To model the dynamic nature of market uncertainty, volatility measures (INFVOL and EXRVOL) were first generated using a Generalised Autoregressive Conditional Heteroskedasticity (GARCH (1,1)) model. This GARCH specification captures time-varying volatility based on past squared errors and previous conditional variance, and is expressed as:

$$\sigma_t^2 = \omega + \alpha \epsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

Where σ_t^2 is the conditional variance, ω is the constant, α is the ARCH term (previous period's squared error), and β is the GARCH term (previous period's conditional variance). The Vector Autoregression (VAR) model serves as the core analytical framework. The VAR is utilized because it treats all four variables as endogenous (mutually influencing), allowing for an investigation of their dynamic interrelationships and feedback mechanisms. The reduced-form VAR model is expressed as:

$$Y_t = c + A_1 Y_{t-1} + \dots + A_p Y_{t-p} + \mu_t$$

Where Y_t is the vector of the four endogenous variables, c is a vector of constants, A_i is the matrix of estimated coefficients, p is the optimal lag length, and μ_t is the vector of white noise error terms.

Diagnostic Testing

Prior to estimation, diagnostic tests were conducted to ensure model validity. The stationarity of each series was confirmed using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, with non-stationary variables transformed via first differences. The optimal lag length (p) for the VAR model was determined using the Akaike (AIC), Schwarz (SIC), and Hannan-Quinn (HQ) information criteria. The data were analysed using Eviews econometric software version 12.

3.2 Data Issues

The study used quarterly time-series data spanning 2007:Q1 to 2024:Q4 (72 observations) sourced from the National Bureau of Statistics (NBS) and the Central Bank of Nigeria (CBN). The variables examined are the Real Return on Pension Funds (RRPF), Real GDP Growth (RGDPG), Inflation Volatility (INFVOL), and Exchange Rate Volatility (EXRVOL).

4. Results and Discussion

This section presents the empirical results from the analyses of the relationships between macroeconomic volatility and the real returns of pension fund investments in Nigeria over 2007Q1–2024Q4. The results are organised sequentially to follow the econometric logic — beginning with preliminary tests, followed by model estimation, diagnostics, and dynamic analyses (Granger causality, Impulse Response Functions, and Forecast Error Variance Decomposition). Interpretations precede each table or figure, and findings are subsequently discussed with reference to relevant literature.

4.1 Preliminary Stationarity and Cointegration Tests

Before estimating the Vector Autoregression (VAR) model, the stationarity properties of the series were assessed using both the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. All variables—Real Return on Pension Funds (RRPF), Inflation (INF), Inflation Volatility (INFVOL), and Real GDP Growth (RGDPG)—exhibited

non-stationarity at levels (ADF $p > 0.05$), while the KPSS test rejected the null of level stationarity for all except RRPF.

Table 1: Stationarity Test Results (ADF and KPSS)

Variable	ADF Stat	p-value	Stationary?	KPSS Stat	p-value	Stationary?
RRPF	-0.776	0.826	No	0.356	0.096	Borderline
INF	0.564	0.987	No	0.752	0.010	No
INFVOL	5.255	1.000	No	0.596	0.023	No
RGDPG	-1.821	0.370	No	0.748	0.010	No

Since most variables are integrated of order $I(1)$, the Johansen cointegration test was performed to determine whether a long-run equilibrium relationship exists among them. As evident in Table 2, the Johansen cointegration test results confirmed one cointegrating relationship among the four variables, implying a stable long-run equilibrium.

Table 2: Johansen Cointegration Test Results

$r \leq$	Trace Stat	95% Crit	Decision	Max-Eigen Stat	95% Crit	Decision
0	54.27	47.85	Reject H_0	27.82	27.59	Reject H_0
1	26.45	29.80	Fail to Reject	19.43	21.13	Fail to Reject

4.2 VAR Estimation and Model Diagnostics

A ten-lag VAR (consistent with AIC/HQIC and the prior study specification) was estimated to capture the dynamic interdependencies among RRPF, INF, INFVOL, and RGDPG. Selected coefficient estimates for the RRPF equation are summarised below.

Table 3: VAR (10) Estimation Results (RRPF Equation)

Variable (Lag)	Coefficient	Std Err	t-Statistic	p-value
L1.RRPF	-0.94	0.21	-4.41	0.000
L1.INF	-2.13	0.98	-2.16	0.031
L1.RGDPG	-2.15	0.83	-2.59	0.010
L2.RRPF	-0.81	0.29	-2.78	0.005
L5.RGDPG	-2.86	1.27	-2.24	0.025
L9.RRPF	0.47	0.20	2.32	0.021
L9.INF	2.15	0.95	2.26	0.024

The negative and significant coefficient on L1.INF indicates that a 1% rise in inflation in the previous quarter reduces real pension returns by roughly 2.13%, confirming inflation's short-run erosive effect.

Table 4: VAR Companion Roots and Stability

Root	Modulus	Stability
1	2.147	Unstable
2	1.374	Unstable
3	1.254	Unstable

Table 5: Residual Diagnostic Summary

Equation	JB p-value	ARCH LM p-value	Ljung-Box p-value
RRPF	0.684	0.590	0.548
INF	0.284	0.699	0.070
INFVOL	0.000	0.858	0.590
RGDPG	0.202	0.642	0.115

4.3 Granger Causality Tests

To verify directional predictability, Granger causality tests were conducted for lags 1–8. The results indicate that $INF \rightarrow RRPf$ and $INFVOL \rightarrow RRPf$ are significant at 1% and 5% levels respectively, whereas $RGDPG \rightarrow RRPf$ is insignificant. Granger causality tests results reveal strong evidence that inflation (INF) and inflation volatility (INFVOL) Granger-cause RRPf, while real GDP growth (RGDPG) does not. This implies that both the level and volatility of inflation are significant predictors of real pension fund returns in Nigeria.

Table 6: Granger Causality (Minimum p-values across Lags 1–8)

Null Hypothesis	Min p-value	Decision
$INF \rightarrow RRPf$	3.7e-07	Reject
$INFVOL \rightarrow RRPf$	0.003	Reject
$RGDPG \rightarrow RRPf$	0.451	Fail to Reject

4.4 Impulse Response Analysis

Impulse Response Functions (IRFs) illustrate the dynamic reactions of RRPf to shocks in the endogenous variables over twelve quarters. Figures 1–4 illustrate the dynamic responses of RRPf to one-standard-deviation shocks in the endogenous variables. Each IRF chart is labeled with quarters on the X-axis and the response of RRPf on the Y-axis. The charts are interpreted below.

Results shown in Figure 1, capturing the response of RRPf to its own shock, reveals that when RRPf gets a positive shock, real returns go up at first, then slowly go down until they settle around zero after a few quarters. This pattern shows that short-term persistence and mean reversion are common in financial return series. It means that pension fund performance has some inertia, which means that strong returns tend to last for a short time before fading away. However, the system is still self-correcting. This dynamic supports the idea that there is short-term momentum but long-term stability, which is in line with the Johansen test's mild cointegration result. This means that portfolio managers can expect real returns to stay the same for a short time, but they shouldn't expect them to stay high for more than a few quarters. The

long-term viability of real returns is contingent upon macroeconomic stability rather than historical performance.

Evidence in Figure 2, which shows the response of RRPF to inflation (INF) Shock, reveals that a one-standard-deviation increase in inflation leads to an instant and steep drop in RRPF, which reaches its lowest point in two to three quarters. The bad effect lasts for almost three years, showing that recovery is slow and not complete. This shows that inflation shocks lower the real purchasing power of pension fund assets, especially in a system that relies heavily on nominal fixed-income instruments like government bonds. The ongoing negative trend indicates that pension fund returns in Nigeria do not fully respond to increasing prices, which goes against the Fisher Effect's prediction of nominal return adjustment. This finding highlights the necessity for inflation-indexed securities and macro-hedging strategies to safeguard the real wealth of pensioners. It also shows that unstable money directly hurts the long-term health of pensions.

Figure 3 results, capturing RRPF to inflation volatility (INFVOL) shock, shows that a shock to inflation volatility causes RRPF to respond negatively for a longer time and more deeply than a shock to the inflation level. The response is still very negative after 10 to 12 quarters, which shows that uncertainty about inflation, not just its level, makes pension returns less stable. This outcome indicates that volatility risk is factored into pension fund performance, and that the conservative investment strategies of PFAs render them particularly vulnerable to macroeconomic uncertainty. It is consistent with the conclusions of Chiang (2024) who underscore the predominance of inflation volatility over mean inflation in elucidating financial instability in emerging markets. The implication of these results for practice is that policymakers should prioritise inflation predictability (stability of expectations) over merely reducing average inflation. The finding indicates that volatility management via dynamic asset rebalancing or volatility-hedging derivatives is essential for the long-term performance of PFAs.

It is evident in Figure 4 which presents how RRPF reacted to a shock in real GDP growth (RGDPG), that an unanticipated positive shock to real GDP growth results in a subsequent decrease in RRPF over the following quarters. This negative reaction could be due to the monetary-tightening channel: strong output growth leads to higher interest rates to keep inflation in check, which lowers bond prices and, as a result, the value of pension portfolios that are heavy in fixed income. While the intensity of this response is lesser compared to inflation or volatility shocks, it remains consistent over the medium term, aligning with the empirical findings of Busse et al. (2014) regarding emerging markets. The results suggest that economic growth alone does not ensure improved pension performance in an unstable macro-financial environment. Policy-induced valuation losses during growth cycles can be lessened if PFAs invest in more than just domestic government bonds.

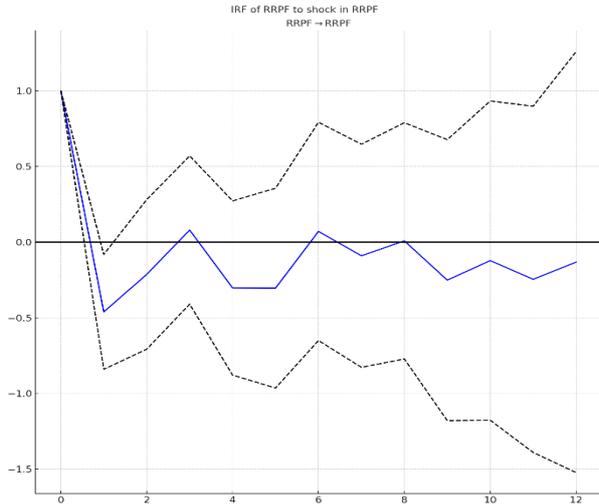


Figure 1: Response of RRPf to its Own Shock
Inflation (INF) Shock

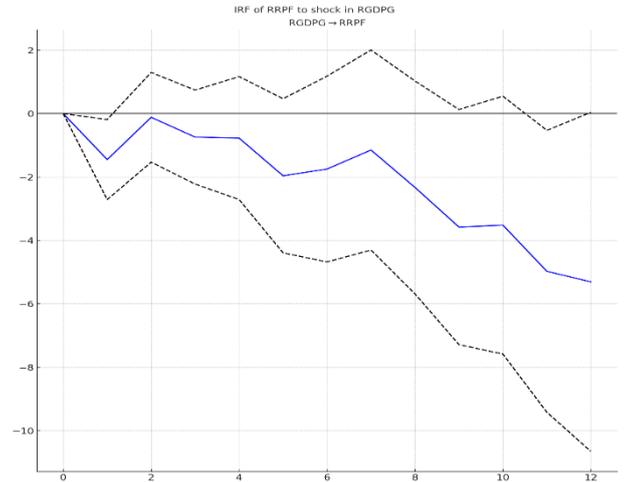


Figure 2: Response of RRPf to

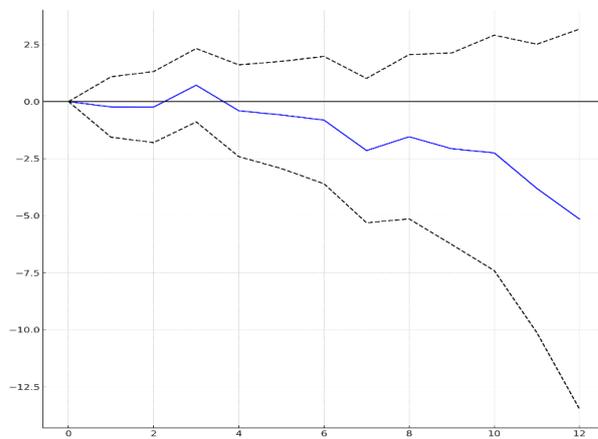


Figure 3: Response of RRPf to Inflation Volatility (INFVOL) Shock
GDP Growth (RGDPG) Shock

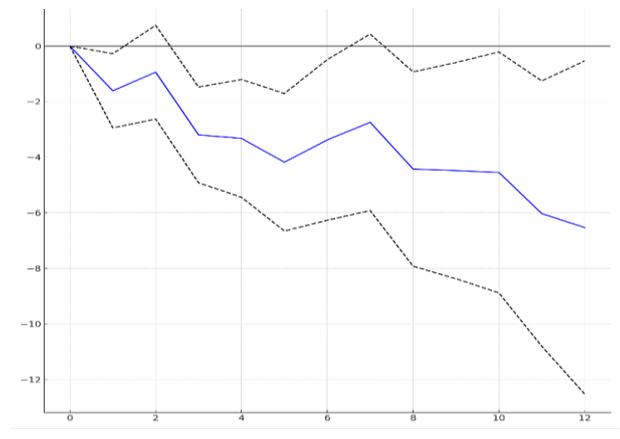


Figure 4: Response of RRPf to Real

Table 8: Summary of Chart Interpretations

Chart	Shock Variable	Effect on RRPf	Duration	Main Mechanism	Policy Implication
Fig. 1a	RRPF	Brief rise, then mean reversion	Short ($\approx 3Q$)	Autoregressive persistence	Past performance not predictive long-term
Fig. 1b	INF	Sharp & persistent negative	Long ($\approx 10-12Q$)	Inflation erosion	Inflation-indexed assets needed
Fig. 1c	INFVOL	Strong, long negative effect	Long ($\approx 12Q+$)	Inflation uncertainty	Prioritize inflation stability & hedging
Fig. 1d	RGDPG	Moderate negative	Medium-term ($\approx 8Q$)	Monetary tightening	Diversify beyond bonds

4.5 Forecast Error Variance Decomposition (FEVD)

To gauge each variable's relative contribution to the forecast variance of RRPF, a 12-quarter FEVD was computed. The Forecast Error Variance Decomposition (FEVD) assesses each variable's relative contribution to RRPF's forecast variance. At a 12-quarter horizon, RRPF's own shocks account for 51% of the variance, while macroeconomic factors jointly explain 49%—comprising inflation (10%), inflation volatility (19%), and real GDP growth (21%). This confirms that macroeconomic dynamics play a central role in determining real pension fund performance.

Table 9: Forecast Error Variance Decomposition of RRPF (12-Quarter Horizon)

Source of Shock	Variance Share (%)
RRPF	51
INF	10
INFVOL	19
RGDPG	21

4.6 Discussion of Findings

These findings provide empirical evidence of a partial Fisher Effect in Nigeria's pension system, consistent with Asemota and Bala (2011) and Awomuse and Alimi (2012), who documented that nominal rates in Nigeria fail to adjust one-for-one with inflation, leaving real returns vulnerable to erosion. The significant effects of inflation and inflation volatility suggest that price instability undermines pension sustainability.

The 21% contribution of RGDP growth demonstrates that macroeconomic expansion affects pension performance primarily through monetary transmission channels, where higher growth leads to policy rate increases and bond price declines, thereby reducing portfolio values. This outcome aligns with Busse et al. (2014) and Sani et al. (2022), who found that cyclical macro policies amplify systemic volatility and asset price adjustments in emerging markets.

This study advances existing literature by integrating macroeconomic volatility into pension fund performance models, addressing the gap left by studies such as Madukwe and Okeke (2022), Fadun et al. (2024), and Oyerinde et al. (2025), which focused on nominal metrics and ignored real value erosion. Unlike those works, this analysis captures dynamic interactions among macroeconomic variables and real returns, offering a comprehensive view of systematic risk.

The findings also bridge theoretical frameworks: while the Fisher Effect explains incomplete nominal adjustment to inflation, MPT accounts for macroeconomic volatility as systematic, non-diversifiable risk. Together, they underscore that stable real returns depend on both sound macroeconomic policy and diversified portfolio construction. In line with Fernández-Villaverde and Rubio-Ramírez (2010), macro volatility acts as an unavoidable systemic factor that cannot be eliminated by diversification alone.

Policy implications are clear. The Central Bank of Nigeria must prioritize anchoring inflation expectations to reduce volatility-driven erosion of pension value. For the National Pension Commission (PenCom) and Pension Fund Administrators (PFAs), diversification into inflation-protected and real assets is vital. This aligns with global recommendations (World Bank, 2023; IMF, 2024) promoting real-return and infrastructure-linked investments for pension resilience.

5. Conclusion and Recommendations

5.1 Conclusion

In conclusion, this study demonstrates that inflation uncertainty—not inflation itself—is the primary systematic risk degrading real pension returns in Nigeria. Sustainable pension performance requires coherent inflation management, predictable macroeconomic policy, and strategic portfolio diversification in line with global best practices.

5.2 Recommendations

- i. The Central Bank of Nigeria should prioritize stabilizing inflation expectations to mitigate the erosive impact of inflation volatility on real pension returns.
- ii. Pension Fund Administrators should diversify portfolios toward inflation-indexed and real assets to hedge against macroeconomic instability.
- iii. The National Pension Commission should strengthen regulatory frameworks that promote risk-based asset allocation and macroeconomic resilience.
- iv. Coordinated fiscal and monetary policies are needed to minimize policy-driven volatility that undermines pension fund performance.

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