# Comparative Analysis of NPS & UPS from an Employee Perspective and Evaluation of Fiscal Implications of Pension Reforms

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**Abstract**

This study provides a comparative analysis of the National Pension System (NPS) and the Unified Pension Scheme (UPS) from the perspective of government employees in India. The research evaluates the financial and fiscal implications of transitioning between these two pension models. While NPS, introduced in 2004, emphasizes market-linked contributions to alleviate fiscal pressure, it is perceived as riskier due to its dependence on investment returns. In contrast, UPS, which offers a defined benefit scheme, ensures guaranteed and inflation-adjusted income post-retirement, reducing market volatility risks but potentially increasing the government's fiscal liabilities. The methodology integrates empirical and computational techniques, including risk-return analysis of NPS portfolios, macroeconomic sensitivity evaluation, and long-term forecasting using machine learning models like TFT, XGBoost and LSTM Networks. The results reveal that although NPS offers higher growth potential, its variability poses challenges for risk-averse employees. UPS, by guaranteeing stability, addresses these concerns but limits growth and imposes less fiscal risks on the government. The study concludes with policy recommendations for optimizing retirement schemes to balance employee security and fiscal sustainability.

Keywords: NPS, UPS, Pension Reforms, Fiscal Implications, Retirement Security, Market-Linked Investments, Defined Benefit Schemes, Macroeconomic Sensitivity, Risk-Return Analysis

## 1. Introduction

The Government of India introduced the Unified Pension Scheme (UPS) after extensive discussions and political deliberations. The growing proportion of revenue expenditure within the total fiscal expenditure had drawn the attention of policymakers to reconsider the sustainability of traditional pension systems. This led to the introduction of the National Pension System (NPS) in 2004, a market-linked pension scheme aimed at reducing the fiscal burden on the government.

However, since its inception, the NPS has been a subject of criticism and dissent, particularly from government employees. This research paper aims to conduct a comparative analysis of the NPS and UPS from the perspective of employees. Key questions explored include: Which system is more beneficial for employees? How secure is the financial condition of a government employee post-retirement? Does the salary guaranteed under UPS outweigh the risk-adjusted returns from the NPS? These and other pertinent questions are addressed in the paper.

At a preliminary level, the NPS is perceived as a riskier mechanism for ensuring financial security after retirement. This perception stems from its market-linked nature, which contrasts sharply with the assured and predictable benefits of the UPS. Government employees, being inherently risk-averse, tend to favour the guaranteed pensions of the UPS, even if the amount is comparatively lower than the potential returns from the NPS. This reflects a behavioural bias, often summarized in economics as: “A guaranteed ₹100 is preferred over a possible ₹1,000 under conditions of uncertainty.”

This paper is structured to provide a comprehensive overview of the National Pension System (NPS) and the Unified Pension Scheme (UPS) for government employees in India. We begin with a contextual overview of both schemes, followed by an examination of the general pay structure for government employees in India. Building upon this foundation, we will review relevant literature and computational methods that can aid in determining the suitability of each scheme.

To achieve this, we will first analyse the risk-return profiles of individual pension fund managers under the NPS. Subsequently, we will assess the response of these funds to macroeconomic shocks, with a particular focus on inflation. Based on these insights, we will employ a temporal fusion algorithm to forecast the expected returns of NPS benchmark funds, utilizing historical performance data and projected economic conditions in India.

Finally, we will simulate a typical NPS portfolio for a government employee, examining the corpus accumulated at retirement under various scenarios. By comparing these outcomes, we will determine whether the NPS or UPS offers greater benefits.

### *1.1. NPS & UPS Overview*

The National Pension System (NPS), introduced in 2004, marked a significant shift from the Old Pension Scheme (OPS), transitioning from a defined benefit model to a defined contribution structure. Under NPS, employees contribute 10% of their salary while the government contributes 14%. Contributions are invested across asset classes, providing flexibility in retirement planning.

A critical component of NPS is the Pension Fund Manager (PFM) selection, where subscribers must choose from a list of PFMs, including HDFC PMCL, ICICI Prudential

PFMCL, LIC PFL, SBI PFPL, and UTI RSL etc. PFMs play a pivotal role in managing the subscriber's contributions, influencing the growth and security of their retirement corpus. Subscribers under the NPS have the flexibility to choose an investment approach that aligns with their financial goals and risk appetite. There are two primary investment options available: Active Choice and Auto Choice. In Active choice subscribers have the discretion to actively allocate their contributions among four asset classes: Equity, Corporate debt, Government Bonds and Alternative Investment Funds. Auto Choice suits those less experienced in managing investments, following a life-cycle fund strategy that adjusts the allocation based on age, automatically reducing exposure to riskier assets (e.g., equity) as the subscriber ages. Auto Choice offers three variations: Aggressive, Moderate, and Conservative, each with a different risk profile.

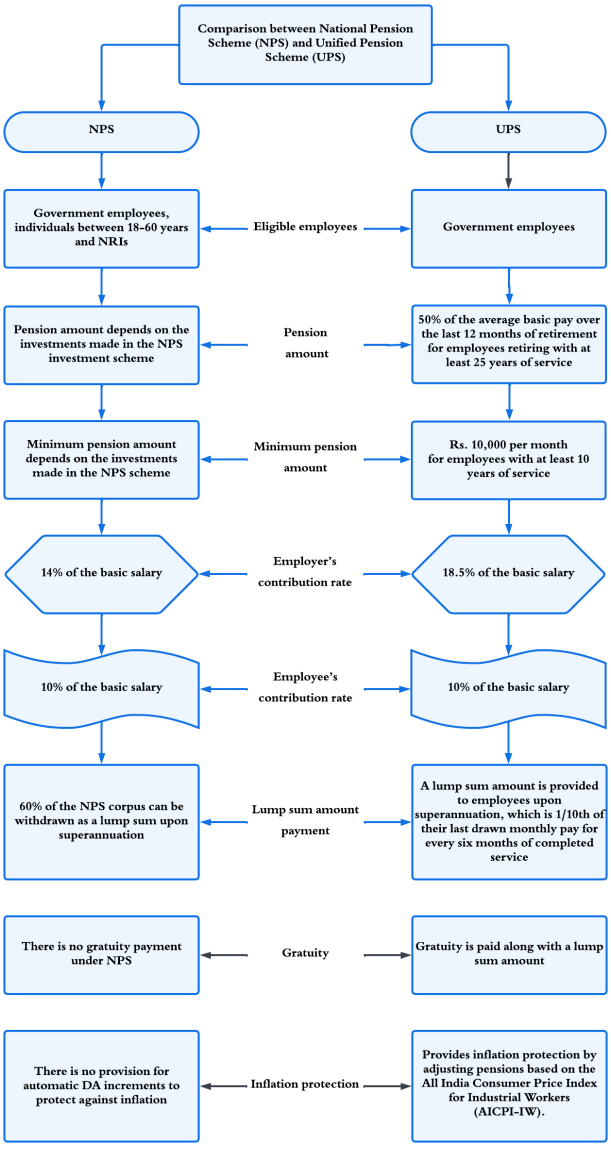


*Figure 1 - Comparison between NPS and UPS*

From an employee's perspective, NPS offers the potential for higher returns through market-linked investments and flexible management options. However, it also introduces challenges, such as market volatility and inflation risks, which can impact retirement savings during downturns. For the government, NPS alleviates long-term pension liabilities (fiscal burden) by shifting some financial responsibility to employees, promoting fiscal sustainability. However, market-driven variability can raise concerns over ensuring adequate retirement benefits for employees.

After 20 years of implementing NPS, Unified Pension Scheme (UPS), set to be implemented from April 1, 2025, introduces a defined benefit pension system aimed at providing stable and predictable retirement benefits for government employees. By moving away from market-dependent retirement savings models like the National Pension System (NPS), UPS focuses on offering guaranteed income, inflation protection, and reduced exposure to market fluctuations.

For government employees, the UPS eliminates the uncertainties associated with market-linked pensions like the NPS. By providing a predictable and stable pension amount, it ensures financial security throughout retirement. Retirees are insulated from economic downturns and market volatility, which can severely impact savings under the NPS. The scheme's inflation indexation feature guarantees that pension payments increase with inflation, protecting the real value of retirees' income over time. UPS's acceptance raises financial concerns for the government when employee-employer contributions and fund performance fall short of minimum guaranteed pension. Even though this method boosts morale and loyalty and helps retain workers by ensuring retirement security.

The UPS has many benefits, but retirees and the government face risks and obstacles. If market performance is weak, the hybrid system could potentially cause financial liability to government. In addition, the UPS's reduced flexibility relative to the OPS may require employees to better understand their pension benefits and market dynamics to maximize retirement results. A defined benefit scheme poses long-term fiscal problems for the government. Pension liabilities are guaranteed; thus the government must cover them, especially when demographics increase pensioners. Inflation indexation and pension payout stability could strain governmental resources.

*Salary Structure Overview*

The salary structure of government employees is a well-defined system designed to provide fair and equitable compensation, ensuring both immediate financial stability and long-term security. It is structured to account for various needs of employees, balancing core earnings with

allowances, benefits, and provisions for retirement. This structure is not only intended to meet the day-to-day financial needs of employees but also to support them in their post-retirement years, particularly through pension schemes like the National Pension System (NPS) and the Unified Pension Scheme (UPS). These pension systems rely on key components of the salary structure, such as Basic Pay, Dearness Allowance, and Other Benefits, to determine the contributions towards retirement funds, ensuring that employees are provided with a comprehensive financial plan both during and after their service.

As a defined-contribution system, NPS uses core salary components such as Basic Pay and Dearness Allowance to calculate contributions, where both the employee and employer make consistent payments towards building a retirement corpus. The government typically contributes 14% of the employee's basic salary, while employees contribute 10%. At retirement, up to 60% of the accumulated corpus may be withdrawn as a lump sum, offering immediate liquidity, while the remaining 40% is used to purchase an annuity, ensuring a steady stream of income during retirement. While this structure grants control over how retirement funds are managed, it lacks certain features like guaranteed minimum pensions inflation protection, which could otherwise shield retirees against rising living costs. Moreover, NPS does not provide gratuity benefits, further distinguishing it from traditional pension models. Family pensions are tied to the accumulated corpus, with annuity plans tailored to the needs of the retiree's beneficiaries. By integrating these technical features, the NPS strives to provide a modernized, market-linked pension solution that adapts to individual needs and long-term economic trends, while leveraging the established salary structure of government employment to drive its contributions.

Under the UPS, pension benefits are determined based on the average basic pay over the last 12 months of service for employees retiring with more than 25 years of service, offering a fixed 50% of this pay as a pension. For those with 10-25 years of service, proportionate benefits are calculated. While this ensures a steady post-retirement income, it lacks the dynamic growth that market-driven investments under NPS can provide. The UPS also offers a minimum pension guarantee of ₹10,000 per month for those with at least 10 years of service, creating a safety net but ultimately capping potential upside growth that NPS subscribers might achieve. Unlike the NPS, the UPS is risk-free regarding market volatility, providing a guaranteed pension amount without exposure to fluctuating markets. This stability comes at the cost of adaptability and limits on long-term growth.

## 2. Literature Review

The evolution of pension systems globally has consistently been shaped by the challenges of fiscal sustainability and demographic shifts, particularly aging populations. This evolution marks a significant transition from Defined Benefit (DB) to Defined Contribution (DC) models, as emphasized by Barr and Diamond (2008). For instance, countries like Chile and Sweden adopted market-linked pension reforms, which provide lessons in balancing individual responsibility with fiscal sustainability (Barr & Diamond, 2008).

Behavioural economics plays a pivotal role in understanding pension preferences. Thaler and Benartzi (2004) demonstrated that loss aversion and risk aversion tendencies drive the preference for guaranteed pensions like the Unified Pension Scheme (UPS). This behavioral insight underscores the psychological appeal of predictable income streams in retirement, especially among risk-averse populations, such as government employees (Thaler & Benartzi, 2004).

Risk-return dynamics in DC systems have been extensively explored in literature. Bodie, Merton, and Samuelson (2009) highlighted the importance of lifecycle adjustments in pension portfolios to mitigate risk exposure as employees near retirement. This is echoed by Blake, Cairns, and Dowd (2008), who emphasized the necessity of inflation-indexed pensions to preserve retirees' purchasing power. Without indexing, retirees are vulnerable to inflationary pressures that erode the real value of their income over time (Bodie et al., 2009); (Blake et al., 2008).

From a fiscal perspective, Holzmann and Hinz (2005) explored the delicate balance in pension reforms between reducing government liabilities and maintaining adequate benefits. The introduction of the National Pension System (NPS) in India reflects this balance, aiming to alleviate fiscal pressures through market-linked contributions while shifting some financial risk to employees (Holzmann & Hinz, 2005).

The use of advanced forecasting models in pension scheme evaluation has become increasingly relevant. Techniques like Temporal Fusion Transformers (TFT), Long Short-Term Memory (LSTM) networks, and XGBoost, as applied in this study, align with findings by Makridakis et al. (2018). These ensemble methods are particularly effective in capturing the complexities of financial time series trends, enabling more robust predictions of pension fund performance under varying macroeconomic scenarios (Makridakis et al., 2018).

Further, the OECD (2019) emphasized the adoption of hybrid pension systems to adapt to evolving economic and demographic trends. Hybrid models that integrate features of both DB and DC systems have shown promise in balancing fiscal sustainability with retirement security. Such models often incorporate guarantees to manage downside risks while providing upside potential through market-linked components (OECD, 2019).

The comparative analysis between NPS and UPS highlights the trade-offs inherent in these systems. The NPS, as a DC system, offers higher growth potential but is susceptible to market volatility. Conversely, the UPS provides guaranteed, inflation-adjusted pensions, addressing concerns of income stability and inflationary risks but increasing fiscal liabilities for the government. This aligns with global trends observed in the literature, where policymakers are increasingly seeking to innovate around these trade-offs.

Overall, the literature suggests that designing effective pension systems requires a nuanced understanding of behavioral tendencies, risk-return trade-offs, and fiscal constraints. Future directions include exploring adaptive hybrid models and employing advanced computational techniques for optimizing pension outcomes under varying demographic and economic conditions.

## 3. Methodology

There are several parts to this methodology section. First, we examine the risk vs. return profile of different fund managers' portfolio schemes under NPS and discuss why this is important. This evaluation is critical from both the employer's and the employee's perspectives.

From the employee's perspective, the primary concern is ensuring financial security during post-retirement life. For the employer, particularly the government, the issue arises if the compensation guaranteed by the employer exceeds the returns generated by the market. In such cases, the accumulated corpus and subsequent monthly pension withdrawn under NPS may fall below what is provided by the traditional Unified Pension Scheme (UPS). If this happens, the government might need to compensate for the shortfall, creating an additional financial burden.

Considering the inherently risk-averse nature of government employees, they are likely to prefer UPS if NPS fails to meet expectations, which could further increase the financial burden on the government. Therefore, understanding whether NPS delivers adequate returns relative to the risks taken and whether this affects post-retirement financial security is critical. Addressing these questions also helps clarify the ongoing debate and concerns raised by those opposing NPS.

Next, we examine the sensitivity of individual NPS schemes and funds to macroeconomic variables. Examples include inflation sensitivity, policy rate sensitivity, and other economic factors. This step helps us infer how different macroeconomic scenarios might affect financial security from an employee's perspective. For instance, during times of economic uncertainty, employees might face behavioral conflicts and stress if they witness poor performance in their pension funds.

Following this, we move on to the core methodology of this paper. We use both historical return data of different NPS schemes and forecast future returns based on classical financial assumptions. The objective is to evaluate whether future NPS returns can match current returns under realistic conditions. This involves simulating various macroeconomic scenarios to observe how the portfolio of a hypothetical government employee would respond to such changes.

Throughout this methodology, certain assumptions are considered for simulation and portfolio estimation. Based on the literature review conducted, we outline these assumptions as follows:

- Employee Profile: A typical beginner-level government employee is assumed to be 25 years old. In this study, we assume the employee joined their job in January 2014, with a gross salary of ₹30,000. This salary comprises 50% basic pay, 42% of the basic pay as Dearness Allowance (DA), and other minor components that are irrelevant for this study. This is because NPS contributions and UPS pension determinations depend primarily on basic pay and DA.
- Salary Growth:
    - DA increases by 3% every six months.
    - Basic pay increases by 3% annually.
- Retirement and Life Expectancy: The employee is expected to retire at the age of 60, with an average life expectancy of 77 years, based on projections for India between 2050 and 2070.

By simulating various scenarios and using these assumptions, we aim to provide a comprehensive analysis of NPS performance and its implications for both employees and employers.

### *3.1 Portfolio Efficient Frontier*

To conduct a comparative analysis between NPS and UPS, it is essential to assess the risk-return profiles of various NPS fund houses to derive meaningful implications. 1) Which fund house is optimal for each auto choice category? 2) whether earnings from the investment can match the market returns or more 3) The predictability and security of pension income under the NPS. 4) The performance of particular scheme components within each fund house across various risk profile groups.

Here we considered the equity, corporate bond, and government bond returns of the top 5 pension fund managers. The equity, corporate bond, and government

bonds for each pension fund manager were considered as separate assets.

**Expected Returns:** The expected returns for each asset were calculated as the average of the difference between the average monthly NAV of the current period and its previous period.

**Covariance Matrix:** A covariance matrix between equity, corporate bond, and government bond returns for a pension fund manager was calculated. This matrix quantifies the relationships between asset returns: Diagonal elements represent the variances of each asset's returns and Off-diagonal elements represents the covariances between pairs of asset returns.

The current risk-free return ($r_f$) is assumed to be 7%, and the allocation for each asset class is determined based on the cap limit for individuals aged 35 and 55 under various schemes, with the primary risk profile focusing on the initiation and conclusion of allocation adjustments.

For each portfolio, the following metrics were computed:

- Portfolio Return (Rp):

$$\boldsymbol{R_p = w^T \mu = \sum_{i=1}^{n} w_i \mu_i}$$

where, w is the portfolio weight vector, and μ is the expected return vector.

- Portfolio Risk (Standard Deviation, $\sigma_p$):

$$\boldsymbol{\sigma_p = \sqrt{w^T \Sigma w}}$$

where Σ is the covariance matrix.

- Sharpe Ratio (S):

$$\boldsymbol{S = \frac{R_p - r_f}{\sigma_p}}$$

The Efficient Frontier is constructed by iterating through all possible weight combinations for three assets, where the weights $w_1$,$w_2$ and $w_3$ satisfy the constraint $w_1+w_2+w_3=1$. For n = 1000 points, random values for $w_1$, $w_2$ and $w_3$ are generated, and the portfolio return ($R_p$), risk ($\sigma_p$), and Sharpe ratio (S) are calculated for each combination. This process results in arrays of returns, risks, and Sharpe ratios, which are used for plotting the Efficient Frontier. The resulting plot is a scatter plot where points represent possible portfolios, coloured according to their Sharpe ratio using a gradient colormap. Specific custom portfolios, including Aggressive (A), Moderate (M), and Conservative (C) life cycles, are highlighted with distinct markers and labels. The portfolio with the maximum Sharpe ratio is prominently displayed with a red star. Additionally, the plot includes a legend and labels for portfolio names, along with a colour bar illustrating the Sharpe ratio gradient for better visualization.

### *3.2 Inflation Sensitivity Analysis*

The methodology centres on the analysis of interdependencies between financial returns and macroeconomic variables using the **Impulse Response Function (IRF)** within the **Vector Autoregression (VAR)** framework. Let $y_t$ represent a vector of endogenous variables, including monthly returns of various funds and macroeconomic indicators (e.g., inflation rate, repo rate, and economic policy uncertainty). The VAR model is specified as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \epsilon_t$$

where $A_i$ are coefficient matrices, p is the lag order determined via the Akaike Information Criterion (AIC), and $\epsilon_t \sim N(0,\Sigma)$ represents the innovation process. The IRF quantifies the time-path of the response of each element in $y_t$ to a one-unit shock in $\epsilon_t$. Given the orthogonalized innovations using Cholesky decomposition, the IRF for a shock to variable j on variable i at horizon h is computed as:

$$IRF_{i,j}(h) = \frac{\partial y_{i,t+h}}{\partial \epsilon_{j,t}}$$

### *3.3 Framework for Long-Term Macroeconomic Forecasting and Scheme Returns*

The methodological approach of this study integrates scenario-based training with time series forecasting methods to estimate macroeconomic trends and predict scheme returns. Using data from economies such as Brazil, China, and South Korea as analogues for India's future growth, the model captures interdependencies and lag structures across time and variables. This approach is premised on the hypothesis that these economies, structurally and demographically similar to India, are 20–40 years ahead in their economic development trajectory.

#### 3.3.1 *Temporal Fusion Transformer (TFT) for Multi-Horizon Forecasting*

The Temporal Fusion Transformer (TFT) is at the core of the forecasting model. TFT is designed for multi-horizon forecasting, combining static and dynamic covariates to process temporal data effectively. This allows the model to predict long-term trajectories of variables like GDP, inflation, and bond yields.

Model Representation:

For time-series data $Xt = \{x1, t, x2, t, \dots, xn, t\}$

at time t, the TFT processes both static covariates (S) and dynamic covariates ($D_t$):

$$\widehat{Y_{t+h}} = f(X_t, S, D_t; \theta)$$

where $\boldsymbol{Y}_{t+h}$ is the forecasted value h-steps ahead, and f is the TFT architecture parameterized by θ. The TFT employs a sequence of attention mechanisms:

$$\alpha_{ij} = \frac{\exp\left(q_i^{\top k_j}\right)}{\sum_{k=1}^{n} \exp\left(\boldsymbol{q_i}^{\top \boldsymbol{k_k}}\right)}$$

where $\alpha_{ij}$ represents the attention weights between feature i and j, and $\boldsymbol{q_i}^{\top \boldsymbol{k_k}}$ are query and key vectors, respectively.

This allows the TFT to assign varying importance to input features dynamically, a critical feature when modelling the influence of macroeconomic variables over time.

### *3.3.2 LSTM Networks for Temporal Dependencies*

Long Short-Term Memory (LSTM) networks are utilized to model sequential relationships and capture temporal dependencies within macroeconomic variables. For a given sequence of inputs$\{X_1, X_2, \dots, X_t\}$, the LSTM outputs hidden states:

$$h_t = f_{\text{LSTM}}(X_t, h_{t-1}, c_{t-1}; \theta_{\text{LSTM}})$$

where $\boldsymbol{h_t}$ is the hidden state, $\boldsymbol{c_t}$ is the cell state, and $\theta_{\text{LSTM}}$ are the parameters of the LSTM. These hidden states are passed to the next layers, enabling the model to account for temporal lags and trends effectively.

The sequential processing of historical data from India's economy allows the model to learn dependencies between variables such as inflation and policy rates over time.

### 3.3.3 *XGBoost with ARIMA Integration*

To capture both linear trends and non-linear relationships within the data, we integrate the Autoregressive Integrated Moving Average (ARIMA) model with XGBoost.

**ARIMA Model:**

The ARIMA model is defined as:

$$\phi(B)(1 - B)^d Y_t = \theta(B)\varepsilon_t$$

where B is the backward shift operator, d is the differencing order, ϕ(B) and θ(B) are polynomials of the lag operator for autoregressive and moving average components, respectively, and $\varepsilon_t$ is white noise.

The ARIMA model captures linear dependencies, which are fed into XGBoost for modelling non-linearities:

**XGBoost Objective:**

$$\mathcal{L} = \sum_{i=1}^{n} \text{l}(\hat{y}_i, y_i) + \sum_{k=1}^{K} \Omega(f_k)$$

where $\mathcal{L}$ is the loss function (e.g., mean squared error), $\Omega(f_k)$ is the regularization term, and $f_k$ represents the k-th decision tree in the ensemble.

### 3.3.4 Scenario Training and Constraints

The methodology incorporates scenario training to simulate India's future economic conditions. Using macroeconomic data from Brazil, China, and South Korea, the model estimates lag structures, τ, which align India's current economic variables, $X_t^{\text{India}}$, with the historical variables of comparator countries:

$$X_t^{\text{India}} = f\left(X_{t-\tau}^{\text{Country}}; \theta_{\text{scenario}}\right)$$

GDP projections for India, spanning 2025–2029, 2036, 2047, 2050, and 2070, serve as constraints, ensuring that the forecasts remain within plausible bounds:

$$\text{GDP}_{t+h} = g(\text{past values}, \text{projected trends}; \lambda)$$

where g is the constraint function and λ represents the GDP projection inputs.

### 3.3.5 Forecasting Scheme Returns

Scheme returns are forecasted by integrating the predicted macroeconomic variables into the model. For a scheme SSS with asset allocations $\{w_E, w_B, w_C\}$ across Scheme E, B, and C, the return is given by:

$$R_t^S = w_E R_t^E + w_B R_t^B + w_C R_t^C$$

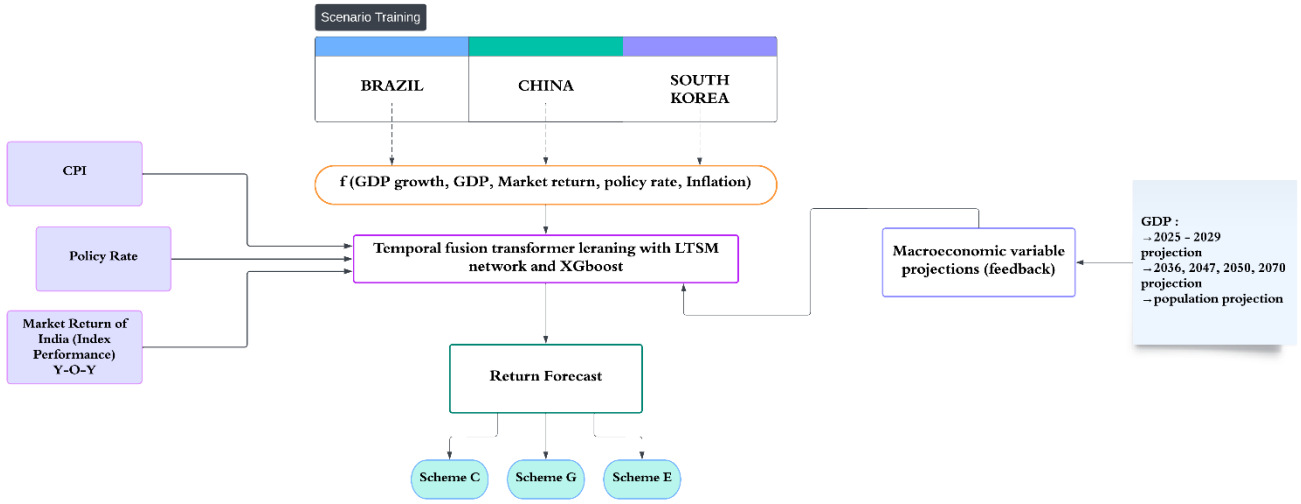


*Figure 2 - Flow Chart of Algorithm for Forecasting Scheme Returns*

## 4 Result

### 4.1 Efficiency Frontiers of Fund Managers

LIC Pension Fund Manager

*Table 1 - LIC Pension Fund EF Summary Statistics*

| Portfolio | Return | Risk | Sharpe Ratio |
|---|---|---|---|
| LIC-A35 | 0.2053 | 0.6007 | 0.2252 |
| LIC-M35 | 0.1385 | 0.3965 | 0.1727 |
| LIC-C35 | 0.0725 | 0.2605 | 0.0094 |
| LIC-A55 | 0.0527 | 0.5636 | -0.0308 |
| LIC-M55 | 0.0399 | 0.6093 | -0.0493 |
| LIC-C55 | 0.0280 | 0.6977 | -0.0601 |

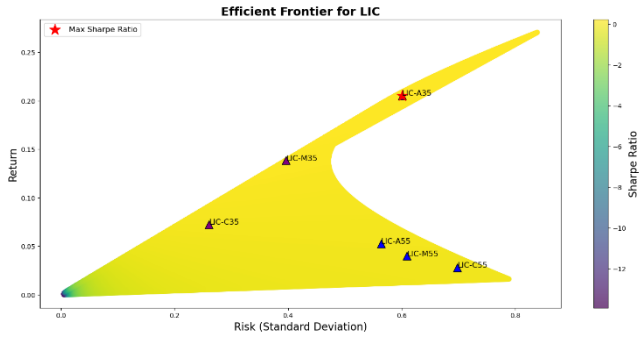


*Figure 3 – Efficiency Frontier for LIC*

The efficient frontier analysis for LIC Pension Fund Manager portfolios highlights the trade-offs between return, risk, and efficiency across life-cycle categories. LIC-A35 (Aggressive, Age 35) achieves the highest return and Sharpe Ratio, indicating optimal risk-adjusted performance. However, as portfolios shift towards conservative strategies (e.g., LIC-C35, LIC-C55) or older age groups (e.g., Age 55), returns decline significantly, and Sharpe Ratios turn negative, reflecting inefficient risk-return trade-offs. These results emphasize the diminishing attractiveness of aggressive and moderate portfolios with age, while conservative approaches fail to compensate for associated risks adequately.

HDFC Pension Fund Manager

*Table 2 - HDFC Pension Fund EF Summary Statistics*

| Portfolio | Return | Risk | Sharpe Ratio |
|---|---|---|---|
| HDFC-A35 | 0.2849 | 0.7401 | 0.2904 |
| HDFC-M35 | 0.2333 | 0.5109 | 0.3197 |
| HDFC-C35 | 0.1817 | 0.2928 | 0.3815 |
| HDFC-A55 | 0.1612 | 0.2344 | 0.3888 |
| HDFC-M55 | 0.1508 | 0.2096 | 0.3856 |
| HDFC-C55 | 0.1405 | 0.1978 | 0.3565 |

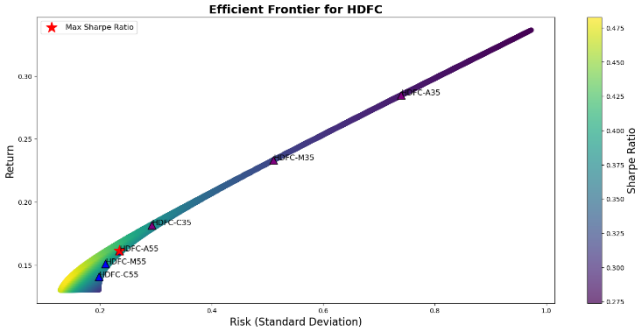


*Figure 4- Efficiency Frontier for HDFC*

For HDFC Pension Fund Manager, portfolios exhibit a clear linear progression along the efficient frontier, with returns increasing alongside risk. Unlike LIC, all Sharpe Ratios for HDFC portfolios are positive, indicating better risk-adjusted performance across all life-cycle categories. HDFC-A35 (Aggressive, Age 35) achieves the highest return, while HDFC-A55 (Aggressive, Age 55) delivers the best Sharpe Ratio, suggesting optimal performance for

older aggressive investors. Conservative portfolios (HDFC-C35, HDFC-C55) demonstrate balanced risk-return profiles but with relatively lower returns, still maintaining positive Sharpe Ratios. This consistency in efficiency highlights HDFC's suitability for varied risk appetites.

ICICI Pension Fund Manager

*Table 3 - ICICI Pension Fund EF Summary Statistics*

| Portfolio | Return | Risk | Sharpe Ratio |
|---|---|---|---|
| ICICI-A35 | 0.3846 | 1.0129 | 0.3106 |
| ICICI-M35 | 0.3191 | 0.7024 | 0.3547 |
| ICICI-C35 | 0.2525 | 0.4081 | 0.4472 |
| ICICI-A55 | 0.2166 | 0.3174 | 0.4620 |
| ICICI-M55 | 0.2026 | 0.2827 | 0.4691 |
| ICICI-C55 | 0.1875 | 0.2643 | 0.4446 |

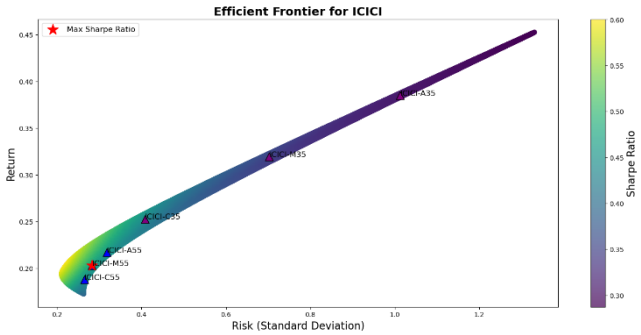


*Figure 5 - Efficiency Frontier for ICICI*

For ICICI Pension Fund Manager, portfolios achieve high returns but at significantly higher risks for aggressive strategies (e.g., ICICI-A35). Interestingly, Sharpe Ratios peak for moderate and conservative portfolios in older age groups, with ICICI-M55 delivering the best risk-adjusted performance (Sharpe Ratio: 0.4691). Conservative portfolios (ICICI-C35, ICICI-C55) maintain strong risk-return efficiency, as reflected in their high Sharpe Ratios, despite lower absolute returns. This indicates ICICI's strength in providing balanced and efficient options across life cycles, particularly for risk-averse or older investors. The results emphasize the suitability of ICICI's conservative strategies for stable, risk-adjusted growth.

SBI Pension Fund Manager

*Table 4 - SBI Pension Fund EF Summary Statistics*

| Portfolio | Return | Risk | Sharpe Ratio |
|---|---|---|---|
| SBI-A35 | 0.3092 | 0.8129 | 0.2942 |
| SBI-M35 | 0.2698 | 0.5701 | 0.3505 |
| SBI-C35 | 0.2303 | 0.3481 | 0.4604 |
| SBI-A55 | 0.2129 | 0.3025 | 0.4724 |
| SBI-M55 | 0.2049 | 0.2831 | 0.4765 |
| SBI-C55 | 0.1967 | 0.2778 | 0.4559 |

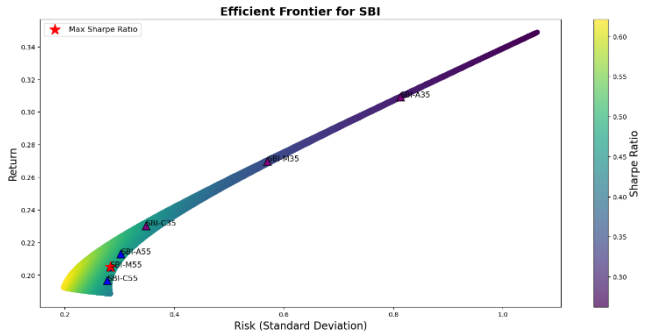


*Figure 6 - Efficiency Frontier for SBI*

For SBI Pension Fund Manager, the portfolios demonstrate a balance between return and risk, with Sharpe Ratios improving significantly in older age groups. SBI-M55 (Moderate, Age 55) achieves the highest Sharpe Ratio (0.4765), highlighting its efficiency in delivering optimal risk-adjusted returns. Conservative portfolios (e.g., SBI-C35 and SBI-C55) also perform well, maintaining stable risk-return profiles. Aggressive strategies (SBI-A35 and SBI-A55) offer higher returns but are less efficient due to higher associated risks. Overall, SBI excels in providing well-balanced portfolios for risk-averse investors, especially in older age groups, while still catering to those seeking moderate growth.

UTI Pension Fund Manager

*Table 5 - UTI Pension Fund EF Summary Statistics*

| Portfolio | Return | Risk | Sharpe Ratio |
|---|---|---|---|
| UTI-A35 | 0.3092 | 0.9951 | 0.2403 |
| UTI-M35 | 0.2698 | 0.6875 | 0.2907 |
| UTI-C35 | 0.2303 | 0.3955 | 0.4053 |
| UTI-A55 | 0.2129 | 0.3105 | 0.4602 |
| UTI-M55 | 0.2049 | 0.2763 | 0.4881 |
| UTI-C55 | 0.1967 | 0.2583 | 0.4904 |

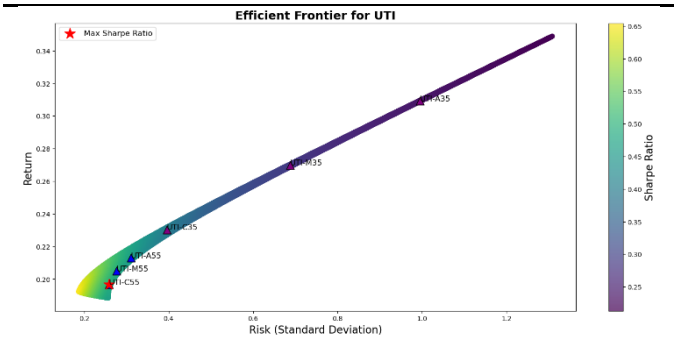


*Figure 7 - Efficiency Frontier for UTI*

For UTI Pension Fund Manager, conservative portfolios dominate in risk-adjusted performance, with UTI-C55 achieving the highest Sharpe Ratio (0.4904). Moderate strategies for older age groups (e.g., UTI-M55) also perform exceptionally well, with a Sharpe Ratio of 0.4881, showcasing strong efficiency. Aggressive portfolios (UTI-A35 and UTI-A55) offer higher returns but are less

efficient due to elevated risk levels, as reflected in lower Sharpe Ratios. UTI's performance highlights its strength in providing optimal solutions for risk-averse investors nearing retirement, while still offering growth options for those willing to assume higher risks.

Important information on how to maximize retirement planning under the National Pension System (NPS) can be found by comparing pension fund managers. There is a recurring pattern: aggressive portfolios, although they generate larger returns, carry higher risks, which makes them less appropriate for risk-averse workers, particularly those in older age groups. On the other hand, moderate and conservative approaches regularly produce better risk-adjusted results, as seen by higher Sharpe Ratios, suggesting that they may be able to guarantee retiring employees' stability and financial security.

Policymakers should think about adjusting pension portfolio defaults according to the age and risk profile of subscribers in light of these findings. For younger workers, a well-rounded strategy that incorporates both aggressive and moderate tactics can manage risk and optimize long-term progress. Conservative tactics should be given top priority for workers who are getting close to retirement in order to safeguard their acquired wealth from market fluctuations and provide a steady income after retirement.

Furthermore, fund managers with superior risk-adjusted efficiency across all life-cycle categories, such as UTI and SBI, ought to be used as standards for performance optimization. For underperforming fund managers, like LIC, whose portfolios show inefficiencies in older age groups, policymakers should enforce stronger performance review standards and promote best practices.

In order to safeguard workers from losing purchasing power after retirement, the government should lastly think about adding inflation-protected plans or hybrid models to NPS portfolios. These actions would boost trust in the NPS, promote wider adoption, and match the financial security of employees with the objectives of budgetary sustainability.

### *4.2 Inflation Sensitivity of Analysis*

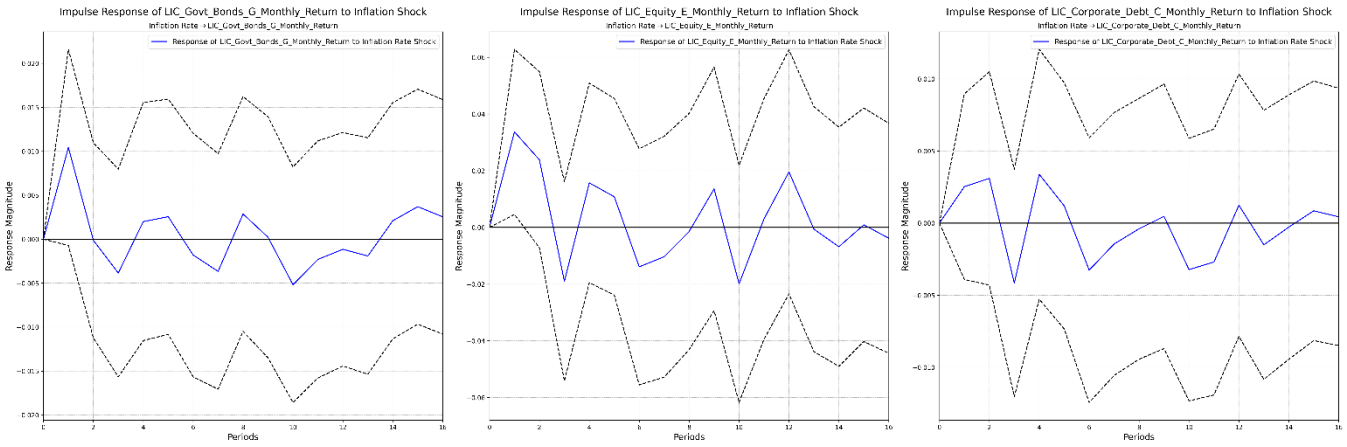


*Figure 8 – IRF Plots of Scheme G, E & C for LIC*

The LIC Pension Fund Manager displays varied inflation sensitivities across asset classes. Equities exhibit pronounced volatility, with an immediate positive response to inflation shocks followed by significant oscillations. This highlights the high sensitivity and unpredictability of equities under inflationary pressures. Government bonds demonstrate a stable response with a small initial increase in returns, gradually declining into negative territory, reflecting their safer but limited inflation-hedging capabilities. Corporate debt shows moderate sensitivity with small initial fluctuations and stabilization around neutral levels over time. Overall, LIC's portfolios reveal equities as the most inflation-sensitive, while government bonds and corporate debt offer relative stability but limited protection against prolonged inflationary shocks.

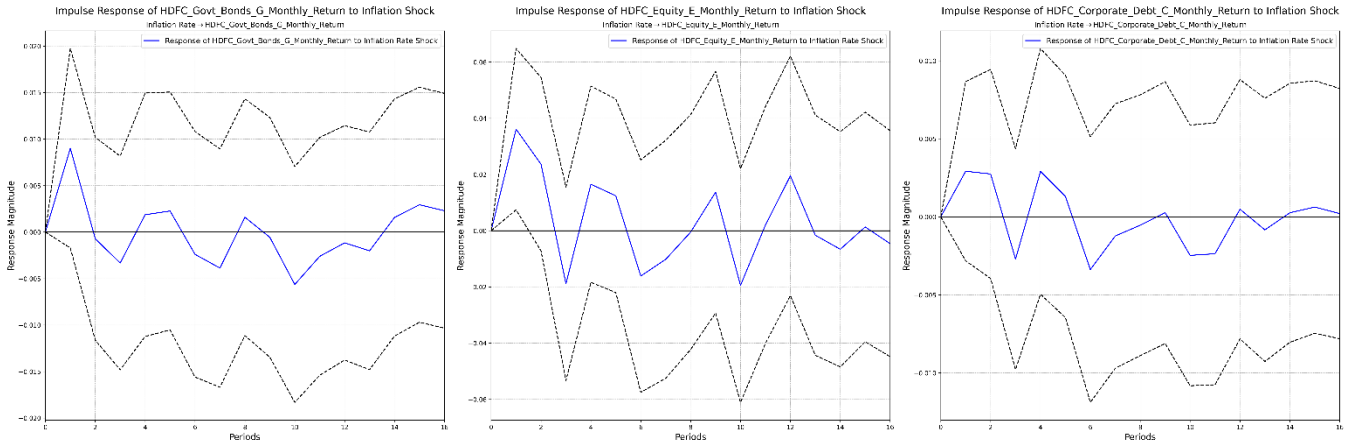


*Figure 9- IRF Plots of Scheme G, E & C for HDFC*

HDFC Pension Fund Manager exhibits varied inflation sensitivity across asset classes. Corporate debt shows a mild initial positive response to inflation shocks, followed by oscillations around zero, reflecting moderate resilience. Equities are highly volatile, with significant fluctuations after an initial positive impact, highlighting their sensitivity to inflationary environments. Government bonds, in contrast, display relative stability, with minor initial gains but a gradual decline, underscoring their safer profile. Overall, HDFC portfolios reveal the importance of balancing high-risk equities with stable government bonds while addressing the moderate sensitivity of corporate debt to inflation.

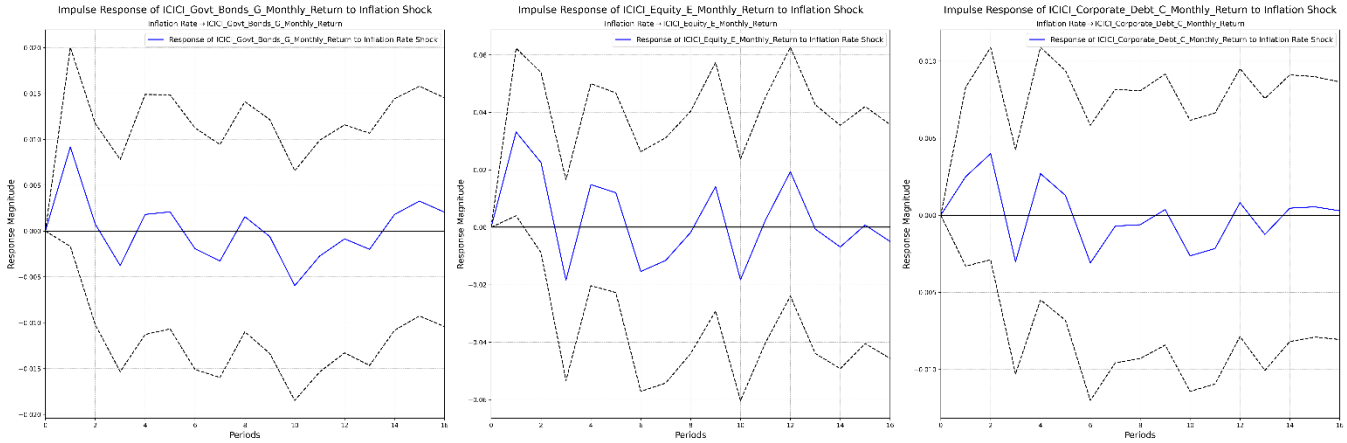


*Figure 10 - IRF Plots of Scheme G, E & C for ICICI*

ICICI Pension Fund Manager demonstrates diverse responses to inflation shocks across asset classes. Equities show pronounced volatility, with strong initial positive responses followed by significant fluctuations, reflecting high sensitivity to inflation dynamics. Government bonds exhibit a steady and subdued response, with minor initial gains transitioning into gradual declines, maintaining relative stability against inflation shocks. Corporate debt shows moderate sensitivity, with minor initial fluctuations that stabilize around neutral levels in later periods. Overall, ICICI portfolios highlight equities as the most inflation-sensitive component, while government bonds and corporate debt provide stability, balancing risk during inflationary conditions.

SBI Pension Fund Manager demonstrates differentiated inflation responses across asset classes. Equities display high sensitivity, with a strong initial positive impact followed by considerable oscillations, reflecting volatility under inflationary pressures. Government bonds exhibit relative stability, with a minor positive initial response transitioning to gradual declines, confirming their role as a steadying asset during inflation shocks. Corporate debt shows moderate sensitivity, with small initial fluctuations and stabilization near zero in later periods. Overall, SBI portfolios effectively balance risk, with equities capturing market sensitivity, while government bonds and corporate debt provide stability and resilience against inflationary impacts.

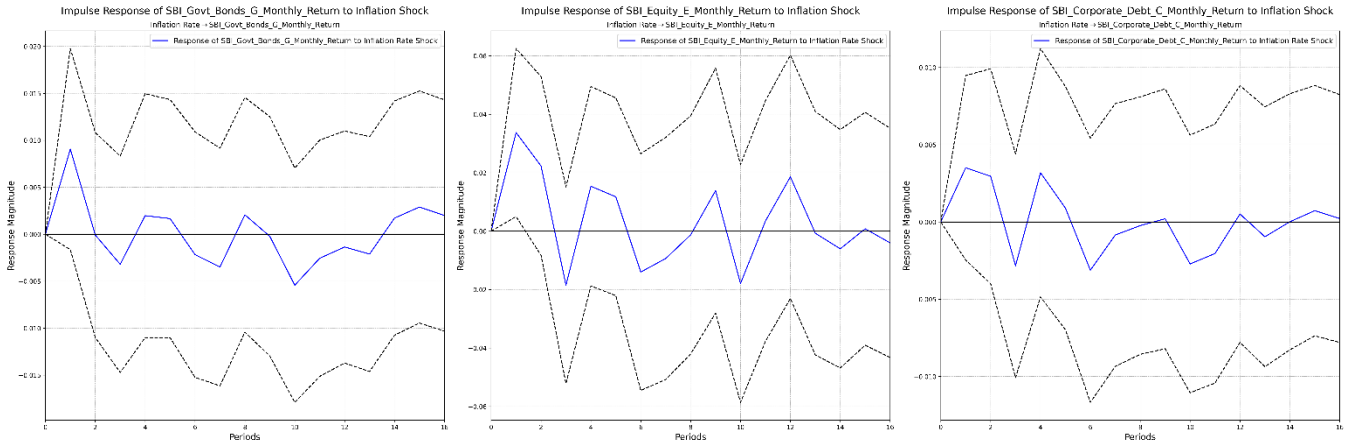


*Figure 11 - IRF Plots of Scheme G, E & C for SBI*

UTI Pension Fund Manager reveals distinct responses across asset classes when subjected to inflation shocks. Equities display significant volatility, with a strong initial positive response followed by sharp oscillations, highlighting their sensitivity to inflationary pressures. Government bonds exhibit relative stability, with a minor positive initial impact that transitions to gradual declines, maintaining their role as a steady asset class during inflation shocks. Corporate debt shows moderate fluctuations initially, stabilizing near neutral levels in subsequent periods. Overall, UTI portfolios effectively balance inflation risks, with equities capturing market dynamics, while government bonds and corporate debt provide resilience against inflationary effects.

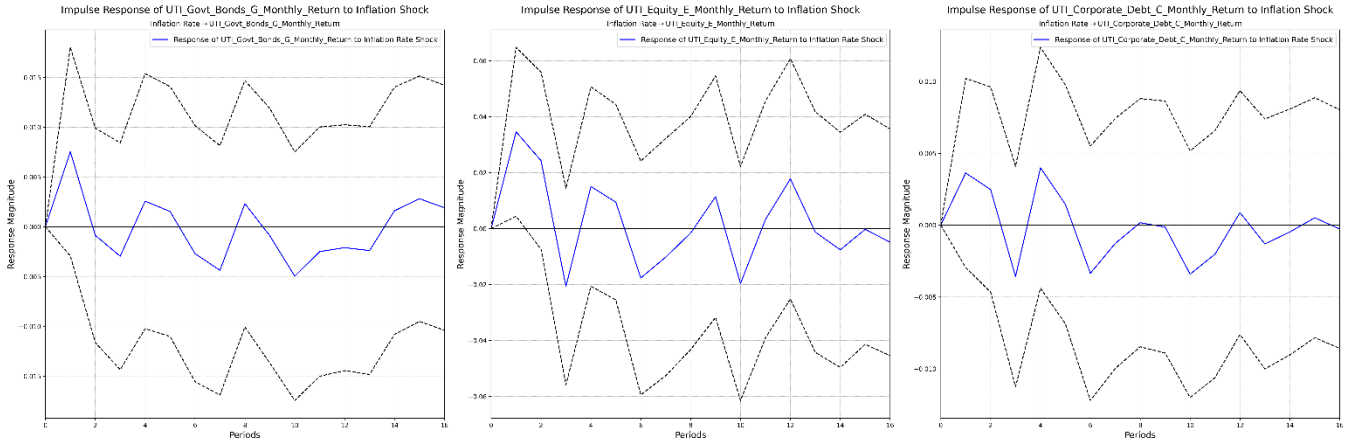


*Figure 12 - IRF Plots of Scheme G, E & C for UTI*

### *4.3 Scheme Return Forecasting Result*

The figure illustrates the forecasted returns for three investment schemes within the National Pension System (NPS): Scheme E (Equity), Scheme C (Corporate Debt), and Scheme G (Government Bonds). As projected, there is a gradual decline in returns across all asset classes over time, a trend that aligns with classic economic assumptions and empirical evidence.

For **Scheme G (Government Bonds)**, the returns exhibit a slow, consistent decline. This behaviour is expected due to improving India's creditworthiness over the long term, reducing the risk premium on government securities and resulting in lower yields. This downward trend in bond yields is further corroborated by macroeconomic trends and historical data analysed in this study.

Similarly, **Scheme C (Corporate Debt)** also shows a gradual reduction in yields. This reflects improving corporate credit environments and narrowing spreads between corporate debt and risk-free government securities over time. In contrast, **Scheme E (Equity)** exhibits a more volatile pattern initially, with high year-on-year (YoY) returns stabilizing and then gradually declining over time. This trajectory reflects the diminishing growth rates of maturing economies and aligns with the underlying assumptions of economic and market dynamics. While equity returns remain higher than fixed-income schemes, the forecasts indicate a converging pattern as the economy stabilizes.

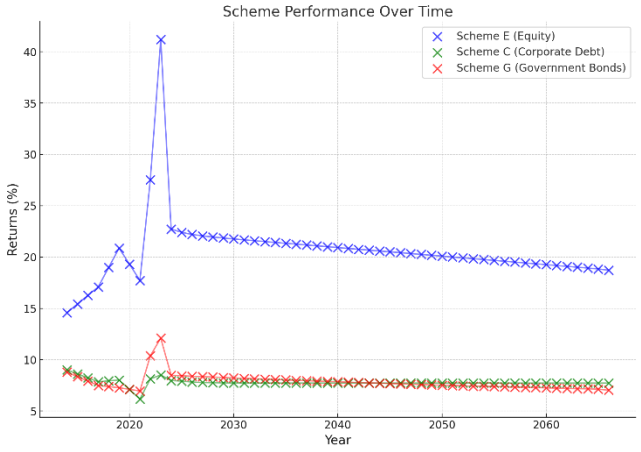


*Figure 13 – Forecasted Scheme Returns*

Our machine learning models, trained using historical data and global economic trends, provided these projections. Notably, the models do not explicitly account for market volatilities observed in real-world cases, such as those in developed markets like the USA. Future iterations will aim to incorporate these factors for enhanced accuracy. This figure, therefore, highlights the importance of understanding and balancing risk-return trade-offs when selecting investment schemes, particularly for long-term financial planning under the NPS.

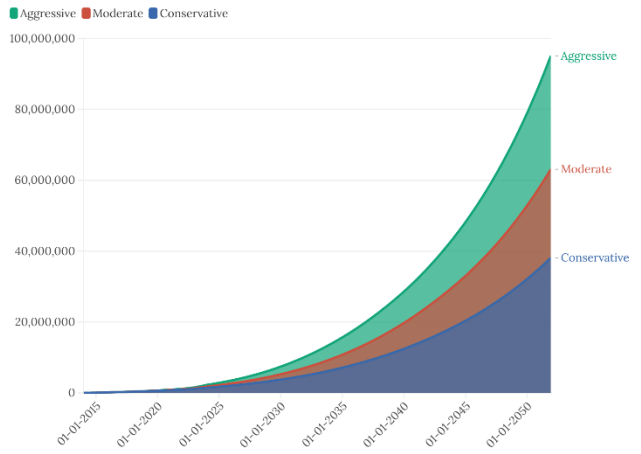


*Figure 14 - Portfolio Corpus Plot for Aggressive, Moderate and Conservative Portfolio with Forecasted Returns*

The figure depicts the cumulative growth of three NPS portfolios—Aggressive, Moderate, and Conservative—over the period from 2015 to 2050. These portfolios, part of the Auto Choice lifecycle strategy, adjust asset allocations dynamically as the subscriber ages, gradually reducing equity exposure while increasing allocations to less volatile asset classes such as corporate bonds and government securities.

In the Aggressive portfolio, equity begins with a high allocation (75%) during the early years but declines with age, reflecting the lifecycle adjustment mechanism. Despite this tapering equity exposure, the Aggressive portfolio achieves the highest corpus growth, exceeding ₹9.8 crore by 2050. This trajectory is driven by higher returns in the initial investment period when equity allocation is at its peak. While this portfolio maximizes long-term returns, it carries greater volatility, particularly in the early years, making it best suited for younger employees who can tolerate market fluctuations.

The Moderate portfolio starts with 50% equity allocation, gradually reducing over time in favour of bonds and government securities. By balancing growth potential and risk reduction, this portfolio accumulates a corpus of ₹7.6 crore by 2050, with a more stable growth trajectory. This option caters well to mid-career employees who seek moderate risk and return trade-offs as they advance in their careers.

The Conservative portfolio has the lowest starting equity allocation (25%), which further reduces with age. This conservative strategy prioritizes capital preservation and stability, accumulating a corpus of ₹5.4 crore by 2050. Its gradual transition toward a high allocation in fixed-income securities ensures protection against market volatility, making it most appropriate for employees nearing retirement.

The results reflect the flexibility of the NPS in accommodating varying risk appetites and investment horizons. The dynamic equity adjustment across all portfolios aligns with the behavioural tendencies of government employees, who often prefer stability as they approach retirement. This age-based lifecycle strategy highlights a key distinction between the NPS and the Unified Pension Scheme (UPS). While NPS offers higher potential returns, its reliance on market performance necessitates informed portfolio selection to align with individual retirement goals and risk tolerances.

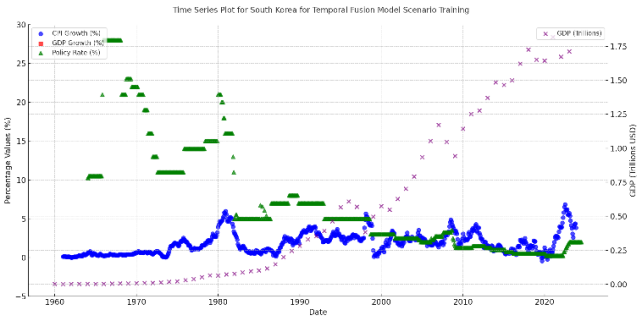


*Figure 15 - Plot of Scenario Training Data of South Korea*

This visualization highlights the macroeconomic trends of countries used to train the scenario models for India, providing critical validation for our underlying assumptions. It confirms key trends, such as the gradual decline in GDP growth rates in percentage terms, the steady reduction in bond yields, decreasing market index performance volatility, and a consistent drop in year-on-year returns over time. These observations align with the broader understanding that volatility and uncertainty are intrinsic to the early stages of a country's economic growth and development.

In the initial phases of economic expansion, countries often experience heightened fluctuations driven by structural adjustments, evolving policy frameworks, and the inherent challenges of establishing growth stability. However, as these economies mature, effective policy regulations and forward-looking growth strategies lead to more stable and predictable economic patterns. While this stabilization often results in lower growth rates and reduced returns, it signifies the achievement of sustainable and steady economic progress.

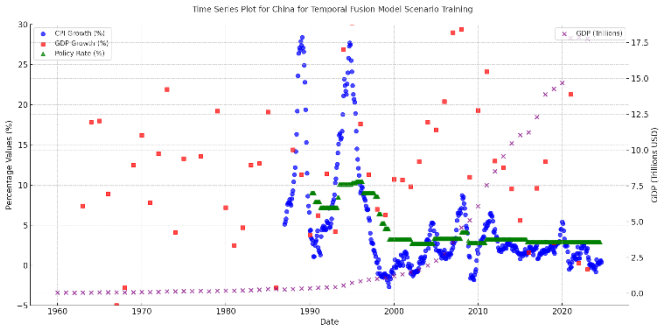


*Figure 16- Plot of Scenario Training Data of China*

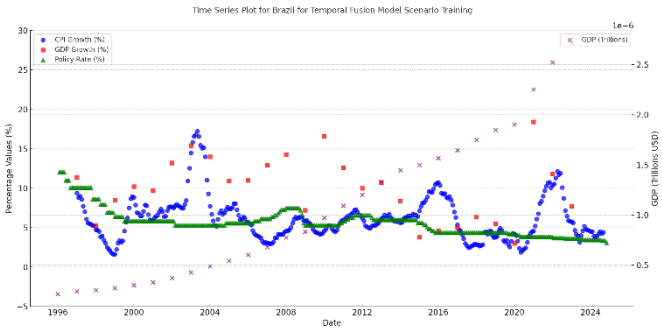


*Figure 17 - Plot of Scenario Training Data of South Brazil*

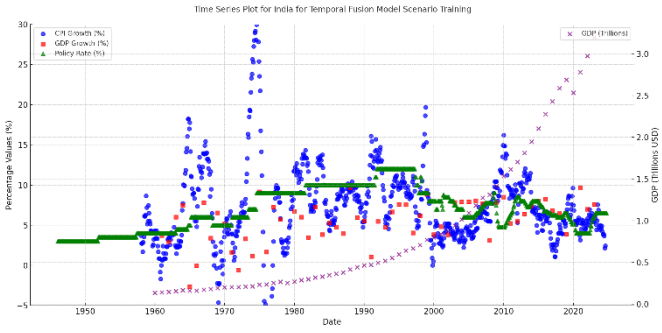


*Figure 18 - Plot of Scenario Training and Macroeconomic Data of India*

India, in this context, is following a similar trajectory but lags behind these countries due to its current stage of economic evolution. The patterns observed in these reference nations suggest that the heightened uncertainties and volatilities in India today mirror the earlier phases of these countries' growth journeys. With successful policy interventions and a focus on long-term growth orientation, India is likely to transition toward the same stable and sustainable economic framework, paving the way for steady growth in the years to come.

## 5 Further Discussion

Pension systems' economic design is closely entwined with more general demographic and budgetary trends, which calls for creative thinking to handle problems particular to India. Understanding the economic forces behind the functionality of the Unified Pension Scheme (UPS) and the National Pension System (NPS) is essential for smart policy development since they reflect very different perspectives. Beyond the structural differences, there are still uncovered major gaps in empirical data and forward-looking models that would provide fresh directions for study and policy formulation.

An important area for more research is on behavioral patterns in pension uptake and optimization. Although most government workers have risk aversion, less is known about how well they might adjust to more market-sensitive pension plans like NPS under various economic situations. Examining how workers interact with dynamic investing tools—such as lifecycle funds or auto-allocation models—can provide practical understanding on how to create user-centric plans.

The distributional effects of pension reforms represent even another urgent problem. With different degrees of financial knowledge, access to investment tools, and socioeconomic pressures across states, regional economic inequalities in India are glaring. Studies should center on how these elements affect pension scheme efficacy in guaranteeing fair retirement security. For instance, the effect of inflation-indexed UPS pensions in inflation-volatile states or the acceptance of NPS in areas with little market penetration could expose policy blind spots.

Macroeconomically, the sensitivity of pension funds to global market volatility still needs more research. Although NPS portfolios incorporate domestic market-linked investments, the possible addition of foreign assets—such as global stocks or ESG-linked funds—might diversify risk but also expose staff to foreign financial shocks. Comparative research on the long-term robustness of such portfolios, learning from international pension systems, will help to clarify their viability for India.

New technologies provide still another avenue for study and debate. Although models of machine learning such as LSTM and TFT show promise for anticipating economic situations, the issue of how such prediction tools translate into practical policy decisions emerges. For instance, can sophisticated forecasting offer real-time triggers for portfolio rebalancing under NPS, and how would such a

process run on scale in India's varied workforce? Moreover, combining these models with localised economic data and behavioural analysis might produce adaptive systems that react dynamically to changes in macroeconomic situations as well as personal subscriber requirements.

One area of mostly untapped importance in pension systems is intergenerational equality. Younger generations may be burdened more financially as India's population ages to maintain assured pensions like UPS. Studies on balancing benefits over generations—perhaps via tiered contribution models or incentivized voluntary programs—may help to clarify how to guarantee long-term equity and sustainability.

Finally, systems of pension program monitoring and governance call for more examination. Although fund performance is the main focus of present monitoring systems, real-time transparency for consumers or responsibility for unsuccessful fund managers receives little attention. Particularly for programs like NPS, developing strong governance structures including employee input, independent audits, and publicly available performance measures could help to increase confidence and involvement.

Finally, the structural and financial subtleties of India's pension systems demand closer investigation of regional dynamics, technological integration, market sensitivity, and equity issues. Driving the conversation outside the conventional wisdom will not only solve current issues but also equip India's pension system for the complexity of a changing workforce and economy.

**Policy Recommendations**

**Adopt a Hybrid Model**: Combine guaranteed income of UPS with NPS's growth potential, allowing flexible transitions between schemes based on employee needs and life stages.
**Ensure Inflation Protection**: Index pensions under UPS and NPS to inflation to preserve retirees' purchasing power, with a guaranteed minimum pension and it's revision.
**Enhance NPS Risk Management**: Introduce stop-loss mechanisms and a government-backed minimum return guarantee of 5%-7% to mitigate market risks for employees.
**Improve Fund Performance**: Conduct quarterly audits of Pension Fund Managers (PFMs) to enforce efficiency and introduce lifecycle portfolios with dynamic allocation based on subscriber age.
**Boost NPS Participation**: Increase tax exemptions, offer matching government contributions for voluntary deposits, and include inflation-linked bonds in NPS portfolios.
**Standardize Pension Policies**: Harmonize benefits for central and state employees and introduce UPS-like schemes for private-sector employees through voluntary participation.
**Encourage Financial Literacy**: Provide tools, workshops, and transparent performance reports to help employees optimize retirement planning and build trust in pension systems.
**Enhance Fiscal Sustainability**: Dynamically adjust contribution rates, diversify UPS reserves into low-risk market instruments
**Regular Policy Reviews**: Form a joint stakeholder committee for periodic reviews to ensure alignment with economic conditions and demographic shifts.

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**Appendix**.

*Table 6- Scheme G*

| Duration | Scheme Benchmark Return |
|---|---|
| 3 months | 3.73% |
| 6 months | 5.87% |
| 1 year | 12.10% |
| 2 years | 10.38% |
| 3 years | 6.95% |
| 5 years | 7.27% |
| 7 years | 7.49% |
| 10 years | 8.78% |

*Table 8- Scheme C*

| Duration | Scheme Benchmark Return |
|---|---|
| 3 months | 2.48% |
| 6 months | 4.22% |
| 1 year | 8.51% |
| 2 years | 8.13% |
| 3 years | 6.16% |
| 5 years | 8.02% |
| 7 years | 7.85% |
| 10 years | 9.00% |

*Table 9 - Scheme E*

| Duration | Scheme Benchmark Return |
|---|---|
| 3 months | 7.75% |
| 6 months | 19.03% |
| 1 year | 41.19% |
| 2 years | 27.52% |
| 3 years | 17.72% |
| 5 years | 20.87% |
| 7 years | 17.09% |
| 10 years | 14.59% |

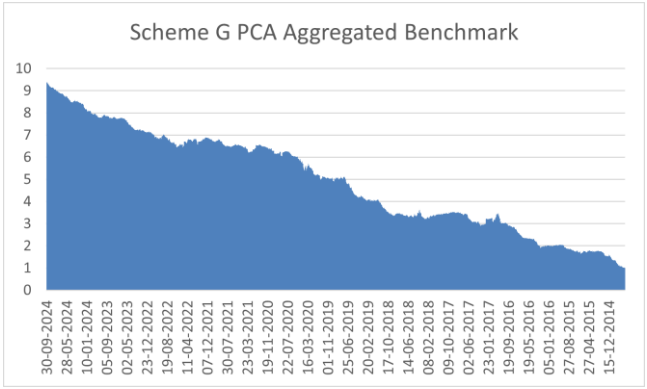


*Figure 19 – Scheme G Normalized Aggregated NAV of Top Five Funds*

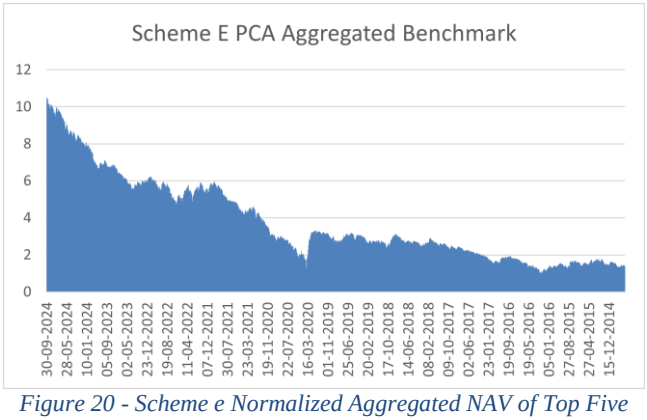


*Figure 20 - Scheme e Normalized Aggregated NAV of Top Five Funds*

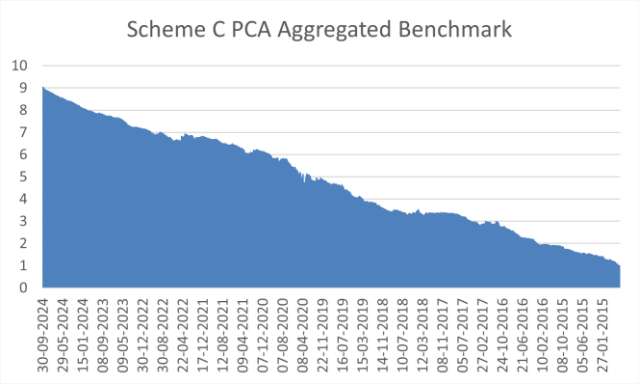


*Figure 21 - Scheme C Normalized Aggregated NAV of Top Five Funds*

*Table 7- Forecasted Scheme Returns*

| Date | Scheme E | Scheme C | Scheme G |
|---|---|---|---|
| 2025 | 22.40598 | 7.92 | 8.43 |
| 2026 | 22.2047 | 7.82 | 8.39 |
| 2027 | 22.06245 | 7.78 | 8.35 |
| 2028 | 21.94973 | 7.76 | 8.31 |
| 2029 | 21.85177 | 7.74 | 8.27 |
| 2030 | 21.76118 | 7.73 | 8.22 |
| 2031 | 21.67429 | 7.73 | 8.18 |
| 2032 | 21.58924 | 7.72 | 8.14 |
| 2033 | 21.50512 | 7.72 | 8.11 |
| 2034 | 21.42146 | 7.72 | 8.07 |
| 2035 | 21.33802 | 7.72 | 8.03 |
| 2036 | 21.25471 | 7.72 | 7.99 |
| 2037 | 21.17145 | 7.72 | 7.95 |
| 2038 | 21.08821 | 7.72 | 7.92 |
| 2039 | 21.005 | 7.72 | 7.88 |
| 2040 | 20.92179 | 7.72 | 7.85 |
| 2041 | 20.83858 | 7.72 | 7.81 |
| 2042 | 20.75538 | 7.72 | 7.78 |
| 2043 | 20.67217 | 7.72 | 7.74 |
| 2044 | 20.58897 | 7.72 | 7.71 |
| 2045 | 20.50577 | 7.72 | 7.68 |
| 2046 | 20.42257 | 7.72 | 7.65 |
| 2047 | 20.33936 | 7.72 | 7.61 |
| 2048 | 20.25616 | 7.72 | 7.58 |
| 2049 | 20.17296 | 7.72 | 7.55 |
| 2050 | 20.08976 | 7.72 | 7.52 |
| 2051 | 20.00655 | 7.72 | 7.49 |
| 2052 | 19.92335 | 7.72 | 7.46 |
| 2053 | 19.84015 | 7.72 | 7.43 |
| 2054 | 19.75695 | 7.72 | 7.41 |
| 2055 | 19.67374 | 7.72 | 7.38 |
| 2056 | 19.59054 | 7.72 | 7.35 |
| 2057 | 19.50734 | 7.72 | 7.33 |
| 2058 | 19.42414 | 7.72 | 7.30 |
| 2059 | 19.34093 | 7.72 | 7.28 |
| 2060 | 19.25773 | 7.72 | 7.25 |
| 2061 | 19.17453 | 7.72 | 7.23 |
| 2062 | 19.09133 | 7.72 | 7.20 |
| 2063 | 19.00812 | 7.72 | 7.18 |
| 2064 | 18.92492 | 7.72 | 7.16 |
| 2065 | 18.84172 | 7.72 | 7.13 |
| 2066 | 18.71682 | 7.72 | 7.03 |