



An Actuarial Approach to Evaluating Returns and Risk Hedging Strategies for Australian Pension Portfolios

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Abstract. In light of growing longevity risk and increased volatility in global markets, this study examines return estimation and hedging strategies for pension investment portfolios within the Australian superannuation system. The purpose of the study is to evaluate how well various hedging strategies improve the sustainability and resilience of a portfolio. The study examines risk exposures and portfolio performance over a long period of time across several schemes using publicly available fund-level data from industry and regulatory sources. Static, dynamic, and non-hedged hedging are the three strategies that are assessed. According to the results, dynamic hedging that is adjusted for past volatility and downside risk metrics like Conditional VaR and Value-at-Risk offers better drawdown protection, better risk-adjusted performance, and steady long-term wealth accumulation. Further research reveals that gender differences in pension outcomes are still present, which raises questions about equity and sufficiency under the current market and policy frameworks. By outlining the benefits of actuarially informed investment strategies and suggesting specific enhancements to portfolio design, regulatory supervision, and personal risk management to promote more robust retirement systems, the study adds to the discussion on sustainable retirement funding.

Keywords: Pension investment, Dynamic hedging, Australian superannuation.

1 Introduction

1.1 Global Context

Globally, ageing populations, longer lifespans, and ongoing low-yield conditions are putting increasing strain on pension systems. The sustainability and sufficiency of retirement income are at risk due to these issues, especially in systems that mainly rely on defined contribution (DC) plans. Portfolio risk management has become more important in this situation.

1.2 Australian Superannuation System

Despite being frequently praised as a well-developed model, Australia's superannuation system is ranked below several European and Asian counterparts in terms of sustainability and adequacy by recent international benchmarks like the Mercer CFA Institute Global Pension Index [1]. Australia is a highly relevant case for assessing risk-adjusted pension investment strategies and investigating policy changes because of the ongoing concerns about gender inequality, benefit volatility, and limited downside protection during market stress.

1.3 Research Approach

This study simulates and assesses the results of pension portfolios under various investment strategies using statistical and actuarial tools. It compares unhedged, static-hedging, and dynamic-hedging strategies under various market conditions using actual Australian fund structures. Value-at-Risk (VaR), Conditional VaR (CVaR), volatility, expected returns, drawdowns, and Sharpe ratios are examples of key performance indicators. To test the robustness of the model, sensitivity analyses are performed across expected return, market volatility, and rebalancing frequency. In order to acknowledge the influence of investment design on social equity, the analysis also takes gender differences in cumulative retirement outcomes into account.

1.4 Research Aim and Contribution

The goal of the study is to identify the hedging strategy that provides Australian pension portfolios with the best return-risk balance. Actuarial modelling and stress testing are combined to support long-term financial planning and strategic asset allocation. This gives fund managers and policymakers practical insights for creating strong, just, and resilient pension systems in the face of future uncertainty.

2 Institutional Context and Structural Analysis

2.1 Trends and Structural Challenges in Australia's Superannuation System (FY2015–FY2024)

Overview of Asset Growth. The main means of accumulating and managing pension assets in Australia's retirement income system are a variety of pension funds, which include self-managed and collective trusts as well as funds from the public and private sectors. These funds are essential resources for long-term wealth accumulation and individual retirement savings. Key structural dynamics, capital flows, and risk concentrations are revealed by examining changes in asset size between FY2015 and FY2024.

Between June 2015 and June 2024, total pension assets climbed by 99%, from roughly AUD 1.98 trillion to nearly AUD 3.94 trillion [2]. The industry remained resilient in the face of market shocks like COVID-19, experiencing only a brief slowdown

from 2020 to 2022 before picking up speed again. All of the main fund categories grew during this time, as seen in Figure 1, with Industry Funds seeing the biggest increase.

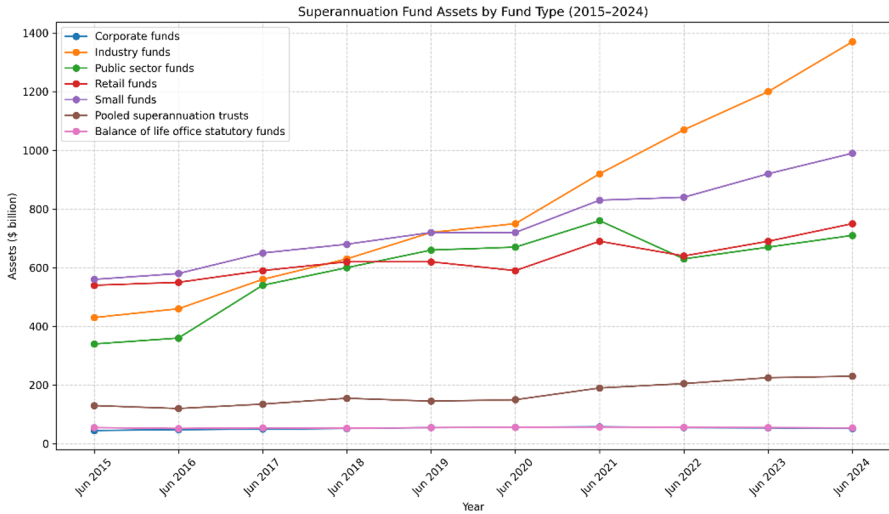


Fig. 1. Superannuation Fund Assets by Fund Type, FY2015–FY2024 [2-4]
Picture credit: Original

Performance by Fund Category. The largest growth among fund types was seen by Industry Funds, which tripled in ten years from AUD 434.3 billion to AUD 1,366.2 billion, making it the largest category since 2018. With the help of high-net-worth asset allocation and self-management trends, small funds also saw significant growth, rising from AUD 554.6 billion to AUD 992.1 billion. Retail funds experienced more moderate growth, with a brief drop from 2020 to 2022, probably brought on by cost pressures and regulatory changes, but they have since recovered. Due to fund exits and consolidation, Corporate Funds saw a minor decline from AUD 5.39 billion to AUD 4.62 billion, while Public Sector Funds continued to grow steadily from AUD 341.6 billion to AUD 718.6 billion. The assets of Pooled Trusts doubled, but Life Office Funds stayed mostly unchanged [2].

Factors Driving Growth Differences. Growth differences between fund types are a result of both macro and micro factors.

1. Policy and regulation: MySuper, Stronger Super, and the "default fund binding" policy were among the reforms that directed contributions towards public and industry funds with low fees and high performance.
2. Performance and fee structures: Industry funds gained greater member trust by outperforming retail funds on net returns and expenses. Weaker players were forced out by the acceleration of mergers after 2018, especially between small business and retail funds.

3. Contributions and demographics: As the population grew older, overall account balances increased due to increases in the employer contribution rate under the Super Guarantee programme [5].

2.2 Institutional Gaps and Structural Risks in Australia's Superannuation Framework

Fund Performance Disparities. Even though all funds are subject to the same regulations, there are notable differences in their long-term performance. Over one and ten-year horizons, Industry Funds outperform Retail Funds by roughly 1.5 percentage points annually, with costs typically 30–40% lower, according to APRA statistics (June 2023) [2]. These cost and performance differences, which are mostly the result of efficient management, offer crucial background information for subsequent modelling that seeks to maximise returns while lowering risk.

Fairness and Coverage Limitations. The average retirement balance for women was 23.1% less than that of men as of 2021 (AUD 146,900 vs. AUD 191,100) [6]. Super contributions, which disproportionately affected women and young part-time workers, excluded workers making less than AUD 450 per month until July 2022. Later in the analysis, gender-specific policy recommendations and a discussion of capital preservation techniques are used to close these equity gaps.

System Efficiency and Complexity. Many employees had multiple super accounts prior to the MySuper reform, which resulted in duplicate fees and insurance costs that were estimated to be AUD 2.6 billion annually in 2019 [7]. Even though account consolidation is not modelled in this report, these inefficiencies highlight how crucial it is to enhance fund structures in addition to investment strategies.

Resilience to Market Shocks. The COVID-19 pandemic revealed weaknesses in the system's resilience to significant downturns. Over 60% of the AUD 37 billion in withdrawals from the 2020 Early Release Scheme came from members under the age of 35, many of whom used up their entire balance [8]. These incidents highlight the applicability of the risk management strategies discussed in later sections, especially dynamic hedging in the face of unfavourable circumstances.

2.3 Data-Driven Insights for Superannuation Risk Analysis

Overview of MySuper Financial Indicators. Understanding current trends in fund performance, membership structure, and demographic trends is crucial for creating successful risk management plans in superannuation. Key MySuper financial indicators from FY2015 to FY2024 are visualised in this section to provide the empirical basis for the ensuing modelling and strategic recommendations.

Total Assets of MySuper Products. The total assets for MySuper products from FY2015 to FY2024 at the start of each fiscal year are shown in Figure 2. From roughly AUD 377.5 billion in 2015 to nearly AUD 995.3 billion in 2024, the data clearly shows an upward trend [9]. Due to increased employer contributions and profitable investment returns, Australia's superannuation system has grown, as evidenced by this growth. The impact of early withdrawals and market volatility brought on by COVID-19 is probably what caused the brief decline in 2020–2021.

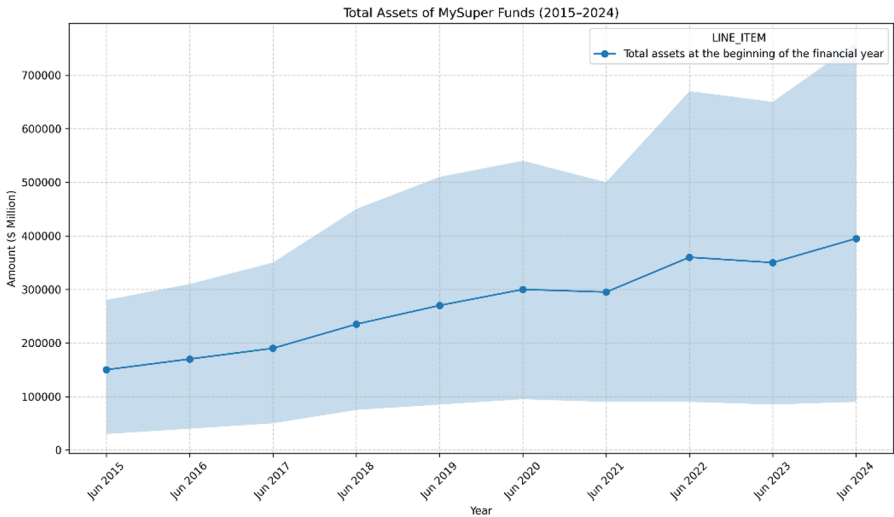


Fig. 2. Total Assets of MySuper Funds, FY2015–FY2024 [9]
Picture credit: Original

Standardised Trends of Key Financial Indicators. Six important financial indicators' min–max normalised values are shown in Figure 3, enabling a direct comparison of trend magnitudes between FY2015 and FY2024. Over time, the inflow and outflow of benefits for members stayed largely stable, with contributions sharply rising around 2022. The most erratic metric was nett investment income, which peaked in 2021 and then fell precipitously in 2022. Both nett growth and nett contribution flows were highly susceptible to outside shocks and moved in tandem. Following normalisation, total assets rose gradually, supporting Figure 3's pattern.

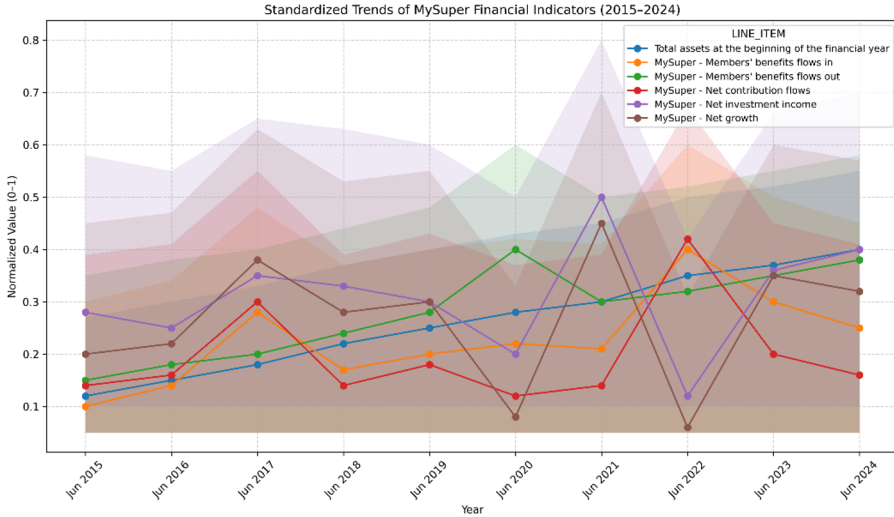


Fig. 3. Standardised Trends of MySuper Financial Indicators, FY2015–FY2024 [9]
Picture credit: Original

Implications for Risk Modelling. The MySuper system has demonstrated strong resilience in asset growth in spite of macroeconomic uncertainties. The biggest short-term risk is still the volatility of investment returns, and a structural reliance on continuous member inflows is indicated by the strong correlation between nett contributions and nett growth. These findings underline the necessity of sound risk-hedging and asset allocation models, which are created in the sections that follow.

Gender Disparity in Superannuation Balances. One of the most prominent equity concerns in Australia's pension system is still the gender disparity in superannuation balances. The average balances for male and female members between 2015 and 2022 are displayed in Figure 4. Even though both sexes saw consistent growth, there is a noticeable and ongoing disparity throughout the whole-time frame.

The average balance for men and women in 2015 was AUD 30,709 and AUD 26,629, respectively. This represents a discrepancy of about AUD 4,080. This disparity grew over time, reaching a high of AUD 10,303 in 2021 [9]. Men continuously held larger balances than women during this time, which may be a result of structural disparities brought on by things like income inequality, caregiving-related career interruptions, and changes in working hours or job types.

Balances for both genders grew more quickly after the COVID-19 era due to market recovery and policy changes. The relative gap, however, stayed constant, indicating that women have not benefited proportionately from these advancements [10]. Targeted policy interventions will be necessary to address this imbalance, and this is taken into account in the modelling and recommendations that follow in this study.

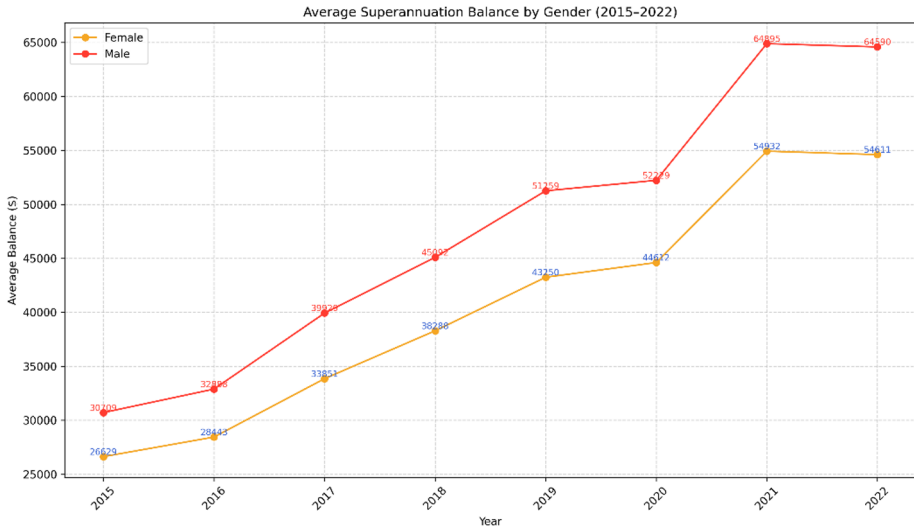


Fig. 4. Average Superannuation Balance by Gender, 2015–2022 [9]
Picture credit: Original

3 Conceptual Framework and Strategic Rationale

3.1 Literature Review on Pension Portfolio Modelling and Hedging Strategies

Historically, pension portfolio design has depended on traditional financial models like the Markowitz Mean-Variance framework, which modifies asset class weights to maximise returns for a given level of risk. Large superannuation funds in Australia use this model extensively in their investment strategies, especially in growth and balanced options [11]. Because it can simulate long-term outcomes under uncertain economic conditions, dynamic stochastic modelling (DSM) has become more and more popular over time, particularly among public funds and MySuper products.

Many Australian super funds continue to use traditional hedging strategies like interest rate swaps and bond-equity diversification. However, dynamic hedging techniques have gained more and more attention, especially in reaction to severe market shocks like COVID-19. Value-at-Risk (VaR) and Conditional VaR (CVaR), two performance metrics, are now commonplace for assessing risk exposure and stress-testing portfolios.

However, the majority of current models presume long-term stability and market normalcy. There aren't many studies in Australia that look at how well hedging strategies work in harsh situations or when fund members' behaviour changes. In order to improve future fund resilience, this disparity emphasises the necessity of conducting empirical comparisons between non-hedged, static-hedged, and dynamically-hedged portfolios.

3.2 Modelling Motivation and Strategic Focus

After reviewing the literature, it is clear that while hedging strategies and classical portfolio models are commonly used in the superannuation industry, there aren't many empirical studies in Australia that thoroughly compare the performance of dynamically-hedged, static-hedged, and non-hedged pension portfolios under actual market uncertainty.

The driving force behind this study is the post-COVID investment environment, which has seen a rise in the need for robust and flexible risk management techniques due to increased market volatility, behavioural shifts, and regulatory tightening. The need for strong hedging mechanisms is further supported by the expectation that MySuper products, which own more than 60% of superannuation assets, will provide default members with stable long-term results [12].

In order to tackle this, we concentrate on three different portfolio strategies: static-hedged, dynamic-hedged, and non-hedged (baseline). These tactics will be covered in detail in the theoretical models that follow. Our aim is to use real pension fund return data and reasonable economic assumptions to model, assess, and contrast them in a consistent framework. By using this method, we can determine which strategy works best in different market conditions and gives fund managers and regulators insights that are pertinent to policy.

4 Theoretical Modelling and Empirical Analysis of Australia's Pension System

4.1 Data Selection and Return Series Construction

Table 1 of the APRA MySuper Annual Bulletin (FY2015–FY2024), which lists the net investment income and total assets of MySuper products at the beginning and end of each fiscal year, provides the investment return data used in this study. The annual nominal return, which serves as the basis for additional performance analysis, is determined using these numbers.

This dataset was selected because it is extremely relevant for policy analysis and represents the actual total investment performance of regulated default pension products in Australia. Additionally, the ten-year coverage offers a consistent historical window that is appropriate for modelling and backtesting. These numbers are more realistic and practically applicable because they are based on actual capital flows and asset valuations rather than hypothetical or model-generated returns.

MySuper nominal returns ranged from -3.78% (2022) to 18.94% (2021), with an average of roughly 7.3% annually, according to the results, which are summarised in Table 1 and illustrated in Figure 5 [9]. The real return series shows a more moderate growth pattern after accounting for inflation (CPI), with some years (2020, 2022) showing negative real returns.

While cumulative real returns were noticeably lower because of inflation erosion, the cumulative nominal return from FY2015 to FY2024 reached 97.87%, nearly doubling the initial investment. Between 2020 and 2022, there is noticeable volatility, which is mostly a result of the COVID-19 pandemic's disruption of the market [9].

Without making any assumptions about a fixed return distribution, this empirical time series is directly used for the ensuing simulation and risk assessment of hedging strategies. When assessing the resilience of static and dynamic hedging strategies, in particular, this method guarantees that the modelling is in line with observed market conditions and offers greater policy relevance.

Table 1. MySuper Annual Investment Performance (FY2015–FY2024) [9]

Year	Nominal Return (%)	Real Return (%)	Cumulative Return (%)
2015	10.34	8.84	10.34
2016	3.76	2.46	14.49
2017	11.77	9.87	27.96
2018	6.67	4.57	36.49
2019	7.86	6.26	47.21
2020	-0.64	-1.54	46.27
2021	18.94	17.64	73.97
2022	-3.78	-9.88	67.39
2023	8.43	4.33	81.50
2024	9.02	5.82	97.87

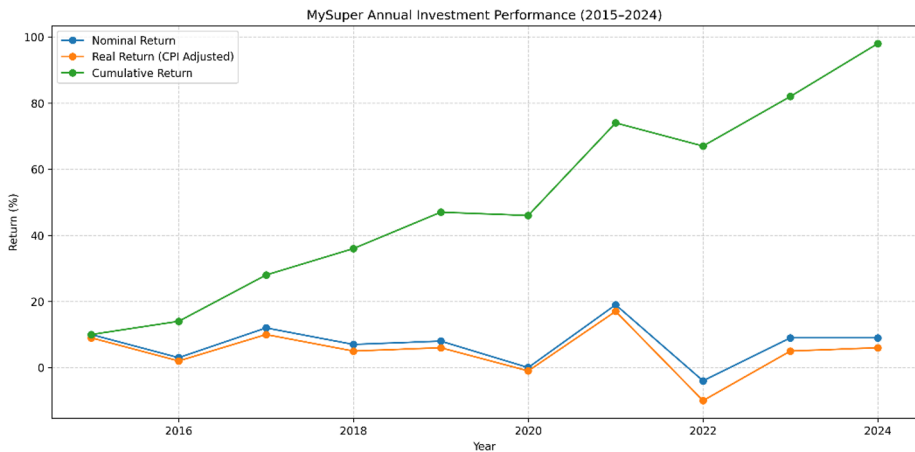


Fig. 5. MySuper Annual Investment Performance (FY2015–FY2024) [9]

Picture credit: Original

4.2 Simulation and Comparative Evaluation of Hedging Strategies

Using MySuper net return data (FY2015–FY2024), three strategies were simulated in order to analyse alternative investment approaches within the Australian superannuation framework:

1. **Non-Hedged:** a 100% equity allocation with no risk management. Although this buy-and-hold strategy is very vulnerable to downturns, it performs best in bull markets.
2. **Static-Hedged (70/30):** A fixed proportion of 30% government bonds and 70% stocks, provides simplicity and stability but is unable to adjust to shifting circumstances.
3. **Dynamic-Hedged:** Allocation changes every year; if the return from the previous year was less than 2%, it switches to 50/50; otherwise, it stays at 90/10, seeks to mitigate losses while capturing growth.

Performance Summary: According to annual returns shown in Table 2 and visualised in Figure 6, non-hedged investors lost money in 2020 (-0.64%) and 2022 (-3.78%), but they made the most in 2017 (11.77%) and 2021 (18.93%). Static-Hedged avoided the losses of non-hedged and was more stable, for example, +0.15% in 2020 [9]. Dynamic-Hedged achieved a balance between the two objectives by limiting losses in down years and producing significant gains in up years.

The cumulative returns over a ten-year period were as follows: 72.11% for Static-Hedged, 95.55% for Dynamic-Hedged, and 97.89% for non-hedged [9]. These findings highlight the trade-off between more stable, slower-growth outcomes and higher returns with more volatility.

Table 2. Annual and Cumulative Returns of Three Strategies (FY2015–FY2024) [9]

Year	Non-Hedged (%)	Static-Hedged (%)	Dy-namic-Hedged (%)	Cum_Non_Hedged (%)	Cum_Sta-tic_Hedged (%)	Cum_Dy-namic_Hedged (%)
2015	10.34	7.84	9.51	10.34	7.84	9.51
2016	3.76	3.23	3.58	14.49	11.32	13.43
2017	11.77	8.84	10.79	27.96	21.16	25.67
2018	6.67	5.27	6.2	36.5	27.55	33.47
2019	7.86	6.1	7.27	47.23	35.33	43.18

(continue) Table 2. Annual and Cumulative Returns of Three Strategies (FY2015–FY2024) [9]

Year	Non-Hedged (%)	Static-Hedged (%)	Dynamic-Hedged (%)	Cum_No n_Hedge d (%)	Cum_Sta tic_Hedge d (%)	Cum_Dy- namic_H edged (%)
2020	-0.64	0.15	-0.89	46.29	35.54	44.16
2021	18.93	13.85	17.24	73.98	54.31	68.99
2022	-3.78	-2.05	-0.89	67.4	51.15	67.49
2023	8.43	6.5	7.79	81.51	60.98	80.54
2024	9.02	6.91	8.32	97.89	72.11	95.55

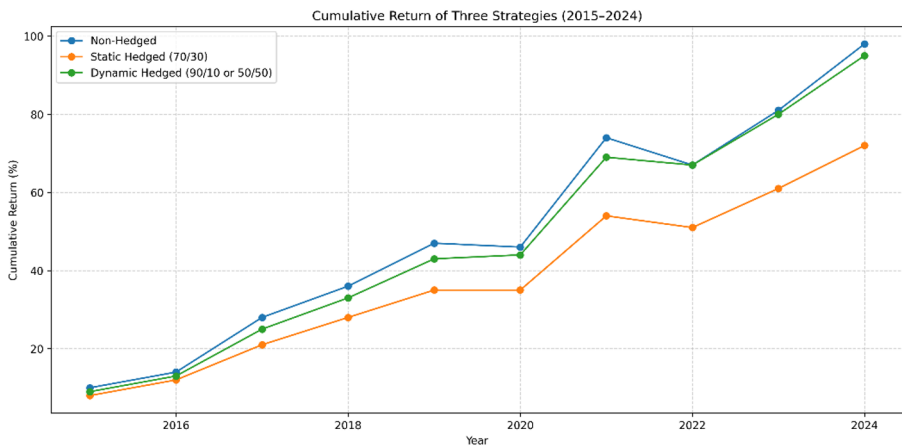


Fig. 6. Cumulative Return of Three Strategies (FY2015–FY2024) [9]

Picture credit: Original

4.3 Performance Evaluation Metrics

Comparing annualised return, volatility, Sharpe ratio, VaR (95%), CVaR (95%), and maximum drawdown allows us to evaluate the three strategies over the fiscal years 2015–2024 (see details in Figure 7 and Tables 3-4). These metrics show both risk exposure and return potential, which is important for long-term superannuation investments.

Results show:

1. Dynamic-Hedged offers the best balance: returns close to non-hedged but with reduced volatility, highest Sharpe, and smallest drawdowns.
2. Non-Hedged captures the strongest upside yet suffers from higher volatility and weaker downside protection.

3. Static-Hedged smooths annual fluctuations but underperforms in cumulative growth.

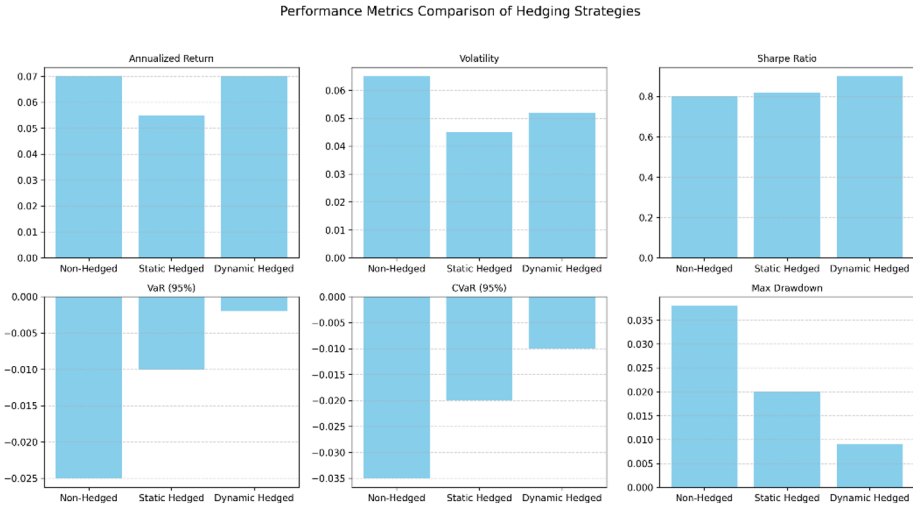


Fig. 7. Performance Metrics Comparison of Hedging Strategies (FY2015–FY2024) [9]
 Picture credit: Original

Table 3. Performance Metrics (FY2015–FY2024) [9]

Strategy	Annual-ized Re-turn (%)	Volatil-ity (%)	Sharpe	VaR (95%) (%)	CVaR (95%) (%)	Max Draw-down (%)
Non-Hedged	7.06	6.39	0.792	-2.37	-3.78	3.78
Static-Hedged	5.58	4.47	0.8	-1.06	-2.05	2.05
Dynamic-Hedged	6.94	5.19	0.951	-0.18	-0.89	0.89

Table 4. 95% Confidence Intervals (FY2015–FY2024, n=10) [9]

Strategy	Mean Return (% , point)	95% CI of Mean (%)	Volatility (% , point)	95% CI of Vol (%)
Non-Hedged	7.24	2.66 — 11.81	6.39	4.40 — 11.67
Static-Hedged	5.65	2.43 — 8.87	4.5	3.09 — 8.21
Dynamic-Hedged	6.89	3.01 — 10.77	5.42	3.73 — 9.90

4.4 Sensitivity Analysis of Dynamic Hedging Strategy

A thorough sensitivity analysis was carried out to evaluate the dynamic hedging model's resilience in various market conditions. Three main parameters were changed by the framework: volatility (3%, 5%, 7%), expected return (5%, 7%, 9%), and frequency

of rebalancing (monthly, quarterly, yearly). With 5,000 Monte Carlo runs, the simulation horizon was set at 20 years. These variants were created especially to show how each component affects long-term return, risk metrics, and overall portfolio stability both separately and in combination.

Impact of Return and Volatility: In all rebalancing setups, higher expected returns typically resulted in significant increases in cumulative wealth; in certain cases, gains from 5% to 9% base returns exceeded 140%. But higher returns also meant more exposure to the downside, as evidenced by more negative Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) figures.

The main risk factor turned out to be volatility. Even when returns and rebalancing settings remained the same, raising annual volatility from 3% to 7% increased maximum drawdowns by an average of over 150%. CVaR values surpassed -8% in the most volatile scenarios, underscoring how susceptible portfolio results are to sharp fluctuations in the market.

Influence of Rebalancing Frequency: The frequency of rebalancing had a significant impact on risk-adjusted returns as well. Stronger downside protection and more seamless wealth accumulation were provided by monthly rebalancing, which continuously produced higher Sharpe ratios and fewer drawdowns across all volatility levels. In order to achieve competitive Sharpe ratios with moderate transaction exposure, quarterly adjustments provided a fair compromise between operational efficiency and responsiveness. On the other hand, in high-volatility markets, annual rebalancing weakened performance, with Sharpe ratios falling by more than 25% when compared to monthly adjustments [13].

Interaction Effects and Key Insights: There were few interaction effects between return, volatility, and rebalancing frequency, indicating that each factor primarily affected performance on its own. The most important factor influencing both return variability and downside risk continued to be volatility. Extreme situations, especially those that combine low returns with high volatility, can drastically diminish the efficacy of dynamic hedging even in a methodical, rule-based framework.

4.5 Gender Considerations in Pension Strategy Application

Women's superannuation balances are generally 30% to 40% lower than men's by mid-career, and the gap frequently widens towards retirement, according to data from the HILDA survey, demonstrating Australia's ongoing gender pension gap [14]. These structural disparities mean that women frequently enter pension investment pathways at a significant disadvantage, which may affect the model's fairness and practical efficacy even though the investment strategy model created in this study is gender-neutral in its design.

Although all investors are subject to the same parameters under the dynamic hedging framework, women may need special calibration due to their typically lower starting balances, longer life expectancies, and more conservative risk tolerance. The strategy might be better suited to this group's requirements with modifications like more frequent portfolio reviews, less aggressive rebalancing thresholds, or lower volatility assumptions.

To lessen these disparities, structural reforms are also necessary. It would be easier to preserve retirement funds during time away from the workforce if mandatory superannuation contributions were extended to cover parental leave or care periods. The gap could be further reduced with additional policies like targeted superannuation bonuses, increased LISTO contributions, or catch-up tax offsets for low-income earners—who are disproportionately women [15].

In conclusion, a route to more equitable retirement outcomes can be found by integrating gender-aware policy interventions with adaptive investment strategy calibration, which makes sure that dynamic hedging techniques don't unintentionally worsen already-existing disparities.

5 Conclusion

According to this study, in the Australian pension context, a dynamic hedging strategy with monthly rebalancing provides the best mix of return, risk, and downside protection. It performs better than static or unhedged strategies in a range of market conditions, exhibiting resilience during erratic times while maintaining long-term capital growth. The findings highlight the necessity of matching portfolio design to return expectations, rebalancing frequency, and market volatility in order to achieve long-term pension results.

In addition to giving fund managers risk-responsive tools, the evidence supports a wider integration of dynamic hedging models into default MySuper products from a policy standpoint. In order to improve the superannuation system's performance and equity, regulatory guidance should promote regular rebalancing while maintaining cost effectiveness.

However, there are still a number of restrictions. Extreme market stress events, like those observed in previous financial crises, are not captured by the comparatively brief back-testing period (FY2015–FY2024). Real-world applicability may also be restricted by presumptions of homogeneous parameters and consistent investor behaviour. Future studies could include scenario testing under extreme shocks, expand the analysis to longer time horizons, and adjust strategies to account for demographic variations like age, gender, salary trajectories, and behavioural responses. These improvements would make pension risk management frameworks more resilient and equitable.

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