Appropriateness of Default Investment Options in Defined Contribution Plans: The Australian Evidence

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Abstract

For participants in defined contribution (DC) plans who refrain from exercising investment choice, plan contributions are invested following the default investment option of their respective plans. Since default investment options of different plans vary widely in terms of their benchmark asset allocation, the most important determinant of investment performance, participants enrolled in these options face significantly different wealth outcomes at retirement. This paper simulates the terminal wealth outcomes under different static asset allocation strategies to evaluate their relative appeal as default investment choice in DC plans. We find that strategies with moderate allocation to stocks are consistently outperformed in terms of upside potential of exceeding the participant's wealth accumulation target at retirement as well as downside risk of falling below that target outcome by very aggressive strategies whose allocation to stocks approach 100%. The risk of extremely adverse wealth outcomes for plan participants also does not appear to be very sensitive to asset allocation. Our evidence strongly suggests the appropriateness of strategies heavily tilted towards stocks to be nominated as default investment options in DC plans unless plan providers emphasize predictability of wealth outcomes over adequacy of retirement wealth.

Key words: defined contribution; default option; asset allocation; retirement wealth; downside risk.

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IN MOST DEVELOPED COUNTRIES, THE COINCIDENCE of a rapidly aging population with a rising proportion of retirees is placing considerable pressure on current social security programs. This demographic trend has resulted in the benefits from social security becoming less certain for future retirees, unless there is a sharp increase in productivity. The situation has prompted policymakers to encourage funded private retirement plans (generally sponsored by employers or other private providers) known as defined contribution (DC) plans, where employee participants build up retirement savings through mandatory or voluntary contributions in their individual retirement accounts. Retirement benefits of participants in these plans are entirely dependent on the accumulation of plan contributions and investment returns earned on those assets. A growing trend in DC plans is to give the individual participants more control over investment of their plan assets. For instance, DC plan participants are expected to select an investment option from a menu of investment choices provided by the plan sponsor. This investment decision is critical because it determines future investment returns on their plan assets, and therefore, influences the wealth accumulated in the retirement account at the end of the participant's working life.

A substantial body of recent research demonstrates that although members of retirement plans have the option to exercise choice, most accept the default arrangements in the plans. The work of Choi, Laibson, Madrian, and Metrick (2003) finds that American employees tend to accept default arrangements in their plans for critical features like contribution rate and investment choice. In their study, up to 80 per cent of assets in different plans are invested in the default fund. In a recent study conducted by Beshears, Choi, Laibson, and Madrian (2006), around 9 out of 10 existing employees who were subject to automatic enrolment in the company retirement plan were found to have some of their assets invested in default fund, with around two-thirds having all their assets in the default fund.

The apparent reluctance of the plan participants to exercise active investment choice is corroborated by international evidence. According to consulting firm Hewitt Bacon and Woodrow, around 80 per cent of group personal pension scheme members in UK accept the default option provided by their plans (Bridgeland, 2002). Similarly, Cronqvist and Thaler (2004) find that since 2003 only 10% of the new participants in Swedish retirement plans actually made any choice. In Australia, about two-thirds of all retirement plan assets are invested in default investment options (Australian Prudential Regulatory Authority (APRA), 2005). It seems that for a large majority of DC plan participants worldwide, the investment of plan contributions are dictated by the default arrangement of their respective plans.

Whether the failure of participants to exercise choice can be attributed to perceived lack of investment knowledge, inadequacy of the choices offered, or anomalies in human behaviour is a topic that has been widely researched and debated in recent times. But given that most plan participants tend to accept default investment options in their plans, perhaps it is more important, from a practical standpoint, to question whether these default investment options are appropriately designed to meet the retirement goals of the participants. This issue has received little research interest, which is surprising because financial well being for majority of plan participants after retirement is directly linked to the performance of the default options. Moreover, international evidence like Blake, Byrne, Cairns, and Dowd (2004) indicates that there is serious lack of agreement on this subject which is reflected in the wide disparity in benchmark asset allocation of default funds chosen by different plan providers.

The question of appropriateness of the default options is no less pertinent for countries where these are less heterogeneous in terms of strategic asset allocation. For instance, Utkus (2004) points out that majority of the plans in the United States (US) choose a money market or stable value fund as default investment option although and that such arrangements are inconsistent with two of the 'prudent investor' principles on asset allocation underlying most participant education programs: first, the existence of positive equity risk premium; and, secondly, the change in the investor's risk-taking capacity with age.[1]

In this paper, we examine the appropriateness of various asset allocation strategies adopted by DC plans in Australia as default options. The importance of asset allocation in influencing investment performance has been well demonstrated by many researchers (Brinson, Hood, and Beebower, 1986; Blake, Lehmann, and Timmermann, 1999). Therefore, one would expect that the asset allocation strategies of default options are decided with utmost care - not only because a majority of participants passively accept the default options offered by their plans - but also considering that there is evidence (Beshears et al., 2006) to suggest that many individuals perceive the default choice as recommendation or endorsement of a particular course of action by the provider. This implies that once the participants get enrolled in the default option in their plans, they are also likely to persist with it for much of their working lives. Given the very long horizon of retirement plan investments, a sub-optimal default asset allocation strategy runs enormous risk for the participants. A mistake committed at the outset is unlikely

[1] Utkus (2004) also observes that extant legal provisions permit investments that result in short-term losses to pursue long term gains and do not require the trustees to invest in 'safe' assets.

to be reversed at a later date and the compounding effect over the long horizon can lead to adverse outcomes, even potentially ruinous in some cases.

To investigate the issue of appropriateness of asset allocation strategies used as default investment vehicles, we find Australian DC plans provide an interesting avenue for research for three reasons. First, Australia has a well established private retirement system with nine out of ten employees currently members of DC plans (APRA, 2005). Since 1992, the Australian Government has made it compulsory for all employers to make contributions to these plans (known as 'superannuation funds') on behalf of their employees (members) at a minimum specified rate (currently nine per cent of wage and salary).[2] Since the post-retirement lifestyle of almost the entire workforce is heavily tied to the value of assets accumulated in their superannuation fund accounts, one would expect the plan providers to design investment strategies, particularly the default strategy, with utmost care. This is also important because contribution rates being equal, the differences in the accumulated value of the plan assets for a vast majority of the members with similar earnings profile is largely reliant on the investment returns generated by the default investment strategy, which in turn is heavily influenced by its benchmark asset allocation.

Second, members in Australian superannuation funds directly confront the classical portfolio choice problem as they are expected to choose an asset allocation strategy (or a combination of strategies) from a menu of pre-selected asset allocation strategies provided by the plan providers to invest plan contributions. This is different from say 401 (k) plans in USA where participants are offered a choice of mutual funds rather than actual asset classes. The default investment choice of every Australian superannuation fund clearly specifies the target allocation among available asset classes; there is no scope for the researcher to make any conjecture about the precise classification of mutual funds and commit any error in the process.

Finally, to examine the issue of effectiveness of any strategic asset allocation policy in the context of wealth accumulation in DC plans, we need to consider its optimality from the perspective of an investor with long horizon, typically equalling the participant's employment life. Many plans like 401 (k) may allow distribution of account balances for participants who change jobs as well as include loan features against account balances, the investment horizon relevant to many participants may actually be much

[2] Many employees are employed under awards that require them to contribute an additional three per cent of wage to superannuation.

shorter. Superannuation funds in Australia, on the other hand, are prohibited from permitting withdrawal of superannuation assets by members before they reach the preservation age (currently 60 years for those born after June 1964).[3] These funds also do not offer any loan feature to members against balance in their individual superannuation accounts. Therefore, the asset allocation structure of the default options offered by Australian pension funds can be expected to be designed from a truly long term perspective and less concerned with the impact of short term volatility in returns on the participant's account balance.

Past research on DC plan investment choices have mostly examined hypothetical asset allocation strategies. In contrast, our study considers asset allocation strategies which are actually used by plan providers as default investment choices. We use more than a hundred years of data for real returns on different asset classes to simulate the retirement wealth outcomes for a typical participant whose plan contributions are invested following the default asset allocation strategies of the top rated superannuation funds in Australia. For the benefit of analysis, we also simulate wealth outcomes under two hypothetical allocation strategies: (i) 100% stocks; and, (ii) default option average (DOA) strategy. The outcomes are then compared to assess their relative appeal to be nominated as default investment option in DC plans. To capture the possibility that past returns on any asset class may not represent the complete range of its expected future returns, we use both parametric and non-parametric methods in this paper to generate simulated returns for the asset classes.

Poterba, Rauh, Venti, and Wise (2006) attempt to rank wealth outcomes associated with different asset allocation strategies for 401(k) plans by using utility function of retirement wealth. However, we use risk-adjusted performance measures in lieu of utility-based framework to avoid making specific assumption about the form of the utility function of DC plan participants. Also, in contrast to most other studies, we consider downside risk (the risk of the participants falling short of reaching their target wealth accumulation at retirement) as an important criterion in selecting an appropriate default strategy for DC plans.

To evaluate alternative allocation rules in terms of their ability to meet the wealth accumulation objective of the plan participants, we employ lower partial moments as robust measures of downside risk and performance measures which are adjusted for downside risk. This paper also considers the

[3] Restricted withdrawals are permitted in some extreme circumstances.

possibility that the risk of extreme events can influence the plan providers' choice of default strategy. We compare these risk estimates under each asset allocation strategy to rank them in terms of their ability to reduce the potential and severity of the most adverse outcomes. Finally, we measure variability of outcomes for every strategy under consideration and compare these estimates as this can form the basis for selection of default in case plans aim to reduce the disparity in wealth outcomes between different employee cohorts.

Our study reports several key findings. First, asset allocation strategies with higher allocation to stocks can be expected to result in higher wealth outcomes for participants. At the same time, the range of wealth outcomes generated by such strategies can also be expected to be wider. Second, the downside risk of falling short of the participant's target wealth outcome gets reduced with increased allocation to stocks in terms of probability as well as magnitude of shortfall. This holds for participants with different levels of risk tolerance. Our results also indicate that on most occasions a strategy which invests entirely in stocks offers highest upside potential and lowest downside risk in relation to retirement wealth accumulated by participants. Third, contrary to popular belief, we find that the potential and severity of the most extreme outcomes for DC plan participants do not seem to increase much with increasing allocation to stocks. In fact, there is little evidence that the extreme downside or tail-related risks of DC plan outcomes are sensitive to the choice of asset allocation strategies. Finally, the lifecycle strategies which are currently used as defaults by a few Australian plans seem to impart little or no protection to participants from downside risk. On the other hand, these strategies are found to considerably erode the value of retirement wealth the participants can potentially accumulate by keeping the initial asset allocation unchanged till retirement. Therefore, like Booth and Yakoubov (2000), we find little basis for plans switching assets as participants approach retirement.[4]

Our findings, although based on simulated wealth outcomes using historical return data for Australian asset classes, may have important implications for default investment options for retirement plans in other industrialised nations. This is because the returns on various asset classes in many of these markets have displayed broadly similar trend over the last century (Dimson, Staunton, and Marsh, 2002).

Turning specifically to the issue of investment horizon, for college and university endowment funds, who traditionally hold a 60:40 mix of stocks and bonds, Thaler and Williamson (1994) demonstrate that an allocation entirely to stocks is likely to provide superior results most of the time. Although individual retirement accounts under DC plans do not have a quasi-infinite investment horizon as enjoyed by university endowment funds, it appears that the typical DC plan participant's holding period of 30 to 40 years may be considered sufficiently long to warrant more aggressive allocation than what is currently chosen by most plan sponsors for their default investment options. Like Poterba et. al. (2006) we find that 100% allocation of stocks is optimal for DC retirement investors but we do not find this optimal allocation rule to change with the degree of risk aversion of the plan participant, especially when we consider performance adjusted for downside risk. Even when the participants demonstrate unreasonably high degree of risk aversion like when they care only about the worst 5 per cent outcomes, the case for plan providers nominating a conservative or balanced strategy as default option does not appear to be strong.

The remainder of this paper is organized as follows. Section I discusses the metrics used to evaluate different asset allocation strategies. Section II describes the simulation methodology and model used to estimate terminal wealth outcomes at the point of retirement. Section III describes the data. Section IV discusses the simulation results, with Section V draws providing concluding comments.

I. Metrics for Evaluating Retirement Wealth Outcomes

To evaluate asset allocation strategies and assess their appropriateness as default investment options in DC plans, we need to make plausible assumptions about the rationale that may guide the selection of a specific asset allocation strategy as default option from many competing candidates. The basic motivation behind instituting retirement savings plans, unarguably, is to generate adequate income for the participating employees after retirement. In that case, performance of DC plans should be measured in terms of their ability to generate sufficient retirement income (Baker, Logue, and Rader, 2005). Therefore, it is assumed that that the principal investment objective of such plans is to maximize the terminal value of plan assets at the point of retirement since that would directly determine the amount of annuity the retiring employees are able to purchase for sustenance during post-retirement life. Past studies have mainly considered the absolute value of the participant's accumulated assets at retirement. However, we employ a ratio which compares the terminal wealth of the participant's retirement account

[4] We desist from drawing any general conclusion on lifecycle strategies since we have very few funds in our sample using such strategies

to their terminal income because it is very likely that the participant's post-retirement income expectations are closely linked to their immediate income before retirement.[5] We call this measure the 'retirement wealth ratio' (*RWR*). To evaluate asset allocation strategies on the basis of terminal wealth outcomes we consider the mean, the median, and the quartiles of the RWR distribution.

Higher estimates of different measures of *RWR* outcomes do not automatically qualify a particular strategy to be selected as default option. The trustees also need to consider the risk associated with investment of plan assets since participants would want a better exploitation of trade-off between risk and reward. In finance, the optimal trade-off between reward and risk is generally determined through Markowitz's (1952) mean-variance analysis. Yet it can be shown that in presence of time-varying investment opportunities, predictable variation in expected equity risk premium, or mean reversion in stock returns, risk can be viewed differently by long-term investors than short-term investors (Campbell and Viciera (2002)). They also point out that mean-variance model also do not allow for periodic rebalancing of portfolio which is essential for long-term investors to maintain their strategic asset allocation. Finally, the use of variance as a measure of risk is questionable especially for long-term investors like DC plan participants. McEnally (1985) shows that the appropriate measure for investment risk is the variability of the terminal wealth outcomes that arise by holding an asset for the intended investment horizon and not the variability of periodic returns of the asset around its average return. This study uses measures of terminal wealth to compute risk (and reward) associated with different asset allocation strategies. However, we consider shortfall below target outcome instead variability of terminal wealth outcomes as measure of risk.

As previously discussed, we assume that the ultimate goal of the DC plan participants is to attain a specific amount of wealth in DC plan account in terms of their terminal income, which we call the target retirement wealth ratio (RWR_T). Under this assumption, the investment risk most relevant to participants is that of failure of their chosen asset allocation strategy to generate RWR_T. This type of 'downside risk' is not new to economics and finance literature. Roy (1952) developed the target rate of return approach in a portfolio selection context where the investor is concerned about minimizing the probability of falling below the disaster level or minimum acceptable rate of return. Mao (1970)

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and the mode of switching is also different from that of typical lifecycle funds in other countries.

[5] This is supported by Booth and Yakoubov (2000), who employ a similar benchmark, that is, the value of accumulated fund at retirement in terms of employee's salary. In addition, this study uses a broader range of metrics in evaluating the risk-reward characteristics of the outcomes.

presents evidence to show that decision makers conceive risk as the possibility of outcomes below target. Olsen (1997) finds that two of the most important attributes of perceived investment risk are potential for below target returns and potential for large loss. We capture these two risk attributes by employing downside risk and tail-related risk metrics respectively.

In this paper, we employ the lower partial moment (Bawa, 1975; Fishburn, 1977) to measure downside risk of different asset allocation strategies. As a risk measure lower partial moment (*LPM*) can accommodate different forms of known Von Neumann-Morgenstern utility functions unlike variance or semi-variance where investor's utility function always needs to be quadratic. *LPM* can represent different attitudes of pension fund members towards risk such as risk averse, risk seeking, and risk neutral. In other words, with *LPM* there is no limitation on the value of the risk aversion coefficient used in investment analysis.

If λ denotes the risk tolerance of the plan participant, then lower partial moment of retirement wealth outcomes is given by:

$$LPM_{\lambda} = \frac{1}{n}\sum_{t=1}^{n} Max[0,(RWR_T - RWR_t)]^{\lambda} \qquad [1]$$

where RWR_T is the target outcome, RWR_t is the outcome for the t-*th* observation, n is the number of observed *RWR* outcomes, and *Max* is the maximization function that selects the larger between the numbers 0 and $(RWR_T - RWR_t)$. The term λ, which is known as the degree of lower partial moment (*LPM*) can theoretically assume any value depending on the risk aversion of the participant.

We compute the lower partial moments for wealth outcomes under different asset allocation strategies for participants with λ = 0, 1, and 2. For λ = 0, LPM_0 gives the probability of shortfall, that is, how often the return can fall below the target although it does not consider how severe the shortfall is likely to be. If λ = 1, LPM_1 weighs shortfalls (RWR_T less below RWR_T outcomes in the context of our problem) with linear weighting. This is also defined as the expected shortfall of the strategy. For λ = 2, LPM_2 gives the below-target semi-variance. Bawa (1975) shows that LPM is mathematically related to stochastic dominance when risk tolerance (λ) is 0, 1 or 2. The choice of appropriate shortfall measure may be guided by the investor's degree of risk aversion (Bawa 1978, Harlow and Rao, 1989) with risk-averse investors choosing LPM with $\lambda > 0$.

We also use performance measures which are adjusted for downside risk in evaluating alternative asset allocation strategies. The concept of downside deviation has been used to suggest several risk-adjusted performance measures, the most well-known among which is the Sortino ratio (SR) introduced by Sortino and Price (1994). This is given by:

$$SR = \frac{RWR_M - RWR_T}{[LPM_2]^{1/2}} \qquad [2]$$

where: RWR_M denotes the mean RWR. The denominator in (2) denotes the downside deviation of wealth outcomes. Due to this formulation, it does not penalise performance for volatility above the investor's target unlike the Sharpe ratio.

Recent research in behavioural finance suggests contrary to the prescriptions of the portfolio theory, individuals may not be seeking the highest return for a given level of risk. Statman and Shefrin (2000) claim that investors seek upside potential from investments while protecting the downside. According to the normative utility function of Fishburn (1977), individuals are risk averse below a minimum acceptable rate of return and risk neutral above it. Sortino, van der Meer, and Plantinga (1999) propose a performance statistic that accommodates the above suggestions by replacing the excess of mean above target in Sortino ratio with the upside potential of the investment, a probability weighted summation of all outcomes which are above the target. This gives the upside potential ratio (UPR) which measures the upside potential relative to the downside risk. In the context of our problem:

$$UPR = \frac{\sum_{RWR_T}^{\infty}\left(RWR - RWR_T\right)}{\left[LPM_2\right]^{1/2}} \qquad [3]$$

Next, we consider the risk of extremely adverse wealth outcomes for plan participants. The psychological concept of loss aversion (Kahneman and Tversky, 1979, Tversky and Kahneman, 1991) is increasingly used in economic analysis. Many authors have suggested that considerations of ruinous loss would affect decisions involving uncertainty (Laughhunn, Payne, and Crum, 1980). Rabin and Thaler (2001) show that reasonable degrees of risk aversion for small and moderate stakes imply unreasonable high degrees of risk aversion for large stakes. If DC plan participants are believed to be loss averse towards the value of their retirement assets, which can be considered as a 'large stake', the plan sponsors may decide to select asset allocation strategies that have more chance of avoiding the most disastrous outcomes. In other words, DC plans would select strategies that lower the estimates of tail risk of the probability distribution of retirement wealth as their default investment option.

To evaluate the extreme retirement wealth outcomes of alternative asset allocation strategies, we use two common measures of estimating tail risk - value at risk (*VaR*) and expected tail loss (ETL). The use of *VaR* in risk management is widespread (Jorion, 2000). In the context of our problem, if *p* represents the probability of worst percentage of *RWR* outcomes that the participants are concerned about, α is the confidence level and *p* is set such that $p = 1 - \alpha$, and if Q_p represents the *p*-quantile of the *RWR* distribution, then the VaR at that confidence level is given by:

$$VaR = Q_p \qquad [4]$$

An outcome worse than *VaR* can occur only in extreme circumstances, the probability of which can be specified by the user by specifying α, which indicates the likelihood that the investor would not get an outcome worse than *VaR*. The higher the degree of risk aversion, higher is the value of α and vice versa.

Yet it has been demonstrated that VaR at a given probability gives us no idea about the amount at risk at higher or lower levels of probability (Balzer, 1994). It also suffers from lack of sub-additive feature and therefore cannot fulfil a necessary axiom of being qualified as a coherent risk measure (Artzner, Delbaen, Eber, and Heath, 1999) . Expected Tail Loss (ETL), which is often forwarded as a better candidate in this regard (Yoshiba and Yamai (2002), Dowd, 2005), gives the probability weighted average of estimates that fall below VaR. In our case, if RWR_i is the i th outcome and i is the probability of the i th outcome, then:

$$ETL_\alpha = \frac{1}{1-\alpha} \sum_{i=0}^{\alpha} RWR_i . i \qquad [5]$$

Therefore, in the context of wealth accumulation of participants, ETL is actually the average of the worst 100(1- α) % of the *RWR* outcomes.

Finally, employee participants belonging to the same plan and following an identical investment strategy but retiring a few years apart can face widely different wealth outcomes (Burtless, 2003). Plan providers may feel that it is important to minimize the disparity in real retirement wealth among different employee cohorts whose investments are governed by the same default strategy.[6] In that case, they would be prompted to select such an asset allocation strategy as default which results in least variation in real retirement wealth outcomes between different employee cohorts, in other words, the real retirement wealth outcomes under different investment return scenarios fall within a narrow range. Our simulations produce a range of possible RWR outcomes for every strategy. The terminal wealth outcome in every case is dependent on the simulated path for asset class returns. Which of these return paths would actually govern the investments of participants following a specific strategy would entirely depend on the future state of the world. The future return path, however, would be identical for participants belonging to the same cohort while it is likely to be different for participants belonging to different cohorts.[7] Therefore participants from different cohorts may have different terminal wealth outcomes even when their investments are directed by identical default option.

To compare the variability of retirement wealth outcomes under different asset allocation strategies, we use two common measures of dispersion. First, we estimate coefficient of variation (CV) for simulated retirement wealth outcomes under every strategy which is the standard deviation of RWR outcomes divided by the mean RWR. To supplement this metric, we also estimate the inter-quartile range ratio (IQRR) which is obtained by dividing the difference between the 75th percentile RWR and the 25th percentile RWR by the median RWR for each strategy under consideration.

II. Model for Generating Retirement Wealth Outcomes

To analyse the wealth outcomes generated by different asset allocation strategies, we use a simple DC plan accumulation model which uses stochastic simulation of asset class returns to determine the

[6] Cross-cohort differences in retirement preparedness as a result of variation in wealth accumulated through retirement plans may also not be desirable from a policy perspective.
[7] It is easy to see that parts of the return paths experienced by different cohorts would be overlapping for the cohorts who share overlapping employment periods.

expected distribution of wealth outcome at retirement. As discussed in previous section, the wealth outcome is measured as retirement wealth ratio (*RWR*). The terminal value of DC plan assets is given by:

$$W = k\sum_{t=0}^{R-1}(1-p_t)S_t(1+r_t)\prod_{u=t+1}^{R-1}(1+r_u) \qquad [5]$$

where: W = value of plan assets accumulated at the point of retirement

k = Plan contribution rate

p_t = Probability of unemployment in year t

S_t = Annual salary in year t

r_t = Real rate of investment return earned in year t

R = Number of years in the plan before retirement

To estimate *W*, we need to model the: (i) contribution cash flows; and, (ii) investment returns for each period. The contribution cash flows depend on annual salary, contribution rate, and probability of unemployment in any period. The annual salary for any year depends on starting wage, wage growth rate, and the number of years elapsed since commencing employment. This is given by:

$$S_t = S_0(1+g)^{t-1} \qquad [7]$$

where S_0 is the starting wage of the plan participant and g is the real wage growth rate. Investment returns are dependent on returns on individual asset classes (included in the portfolio) and the weights assigned to them. The latter is determined by the asset allocation strategy of the plan. Mathematically:

$$r_t = \sum w_{i,t} r_{i,t} \qquad [8]$$

where: $w_{i,t}$ is the weight assigned to the i^{th} asset in year t and $r_{i,t}$ is the real return on the i^{th} asset in year t

We base our analysis on simulated wealth outcomes for an employee who joins the plan at the age of 25 years and retires at the age of 65 years. The starting salary of the employee is assumed to be 25,000 Australian Dollars and the growth in real wages to be two per cent per year, which closely follows growth rate of Australia's real GDP per capita of 2.6 per cent per annum from 1994 through 2004 (Australian Bureau of Statistics, 2005). The contribution rate is fixed at nine per cent which is the legislated minimum prescribed by the Australian government. No contribution is made during periods of unemployment, the probability of which is assumed to be five per cent. This is equal to the unemployment rate among Australian workers with post-school qualifications (Kryger, 1999; Richardson, 2006). For the sake of simplicity, we assume that the contributions are credited annually to the accumulation fund at the end of every year (in practice, the Australian Government has recently legislated that contributions needs to be made, at a minimum, on a quarterly basis). The portfolios are also rebalanced at the end of each year to maintain the target asset allocation. We assume that plan contributions and investment returns are not subject to any tax. We also ignore any transaction cost that may be incurred in managing the investment of the plan assets.

For generating asset class returns, this study initially employs Monte Carlo simulation which estimates statistical parameters from historical data series under assumed theoretical distribution and then exposes these to random changes in simulating future outcomes. Following standard Monte Carlo simulation methodology, we assume that asset class returns are drawn from a multivariate normal distribution. This implies that mean and standard deviation of asset class returns are time invariant and the returns are independent over the time horizon. At each stage of the simulation horizon, the random shocks generated by the multivariate normal model are adjusted so as to follow the average cross-sectional correlation observed in the historical data.

Since Monte Carlo simulation imposes explicit distributional assumption in generating asset class returns, we run a parallel test for generating wealth outcomes using non-parametric bootstrapping which draws asset class returns from the empirical return distribution. Here the historical return data series for the asset classes is randomly resampled *with replacement* to generate portfolio returns for every period of the 40 year investment horizon of the DC plan participant. In other words, each bootstrap sample is a random sample of asset class returns for a particular period drawn *with replacement* from historical observations over several periods. Thus we retain the cross-correlation between the asset class returns as given by the historical data while assuming that asset class return series is independently distributed over time.

III. Data

To investigate the issue of strategic asset allocation for long horizon investors like DC plan participants it is essential that we generate simulated returns based on historical observations of asset class returns over several decades. This is done to minimize the undue influence that recent investment performances (of these asset classes) may have on long-term risk assessment and asset allocation decisions. Moreover, it is argues that a longer period of data has greater chance of capturing the wide-ranging effects of favourable and unfavourable events of history on returns of individual asset classes. Since participants are likely to be concerned with the effect of inflation on the value of their retirement wealth, we need to use real investment returns to simulate terminal wealth outcomes for different asset allocation strategies. This paper uses an updated version of the dataset of returns on stocks, bonds, and bills originally compiled by Dimson, Marsh, and Staunton (2002) and commercially available through Ibbotson Associates for 16 countries including Australia for a period of 105 years spanning from 1900 to 2004. All returns are annual real returns and include reinvested income and capital gains.

For the full 105 year period from 1900 to 2004, the mean annual real return for Australian stocks has been 9.09 per cent while the same for Australian bonds and bills has been 2.27 per cent and 0.72 per cent respectively. When we consider only data after the Second World War, from 1947 through 2004, the mean annual real returns for the three asset classes were smaller, recorded at 8.05, 1.08, and 0.62 per cent for stocks, bonds, and bills respectively. However, real returns for all three classes seem to have been significantly higher in recent times. During the most recent 30 year period in our dataset, 1975 through 2004, mean annual real returns for stocks, bonds, and bills have been 10.93, 4.97, and 3.20 per cent respectively. Going by the higher mean real returns produced by stocks, one would also expect much higher standard deviation for stocks in comparison to that for bonds and bills. This has exactly been the case with the standard deviation of annual real returns on stocks, bonds, and bills being 17.74, 13.36, and 5.51 per cent from 1900 through 2004. The corresponding estimates for post war period (1947-2004) were 21.06, 11.47, and 5.09 per cent while those most recent 30-year period (1975-2004) were 20.54, 11.13, and 3.76 per cent.

Since DC plan participants have long investment horizons, typically between 30 and 40 years, asset class returns for long holding periods would be of more interest in examining their case. From asset class return data between 1900 through 2004, we find that the real returns from bonds have been negative for 29 of the 76 observed 30 year holding periods and 20 out of 66 observed 40-year holding periods. Bills recorded further underperformance with 32 of the 76 observed 30-year holding periods and 20 of the 66 observed 40-year holding periods yielding negative real returns for the investors. In contrast, the real returns from Australian stocks for every 30-year and 40-year holding periods between 1900 and 2004 were positive. The real equity premium over bond and bills has also been positive for each of these holding periods.

We also use data on default investment strategy for major Australian superannuation funds. In Australia, it is a regulatory requirement for trustees to identify a default strategy where investment choice is offered to standard employer-sponsored members. Most superannuation funds offer a balanced diversified investment strategy to their member participants as the default investment choice. The guidelines for trustees provided by the regulatory authority emphasises the benefits of diversification as, according to them, it would 'result in a lower overall level of risk to achieve desired return' (APRA, 1999). At the end of June 2004, the majority of default strategy assets of superannuation funds were held in stocks: 33 per cent in Australian stocks and 21 per cent in international stocks. A further 15 per cent was invested in Australian fixed interest, 6 per cent in international fixed interest, 7 per cent in cash, 6 per cent in property, and 12 per cent in other assets (APRA, 2005).

In 2005-06, SuperRatings, an independent research house, conducted a comprehensive analysis of 120 superannuation funds including major industry, corporate, and public sector funds as well as commercial master trusts, most of which hold more than $500 million of assets.[8] Together, the funds cover in excess of $300 billion of retirement savings on behalf of nearly 10 million member accounts. The funds are rated on the basis of their performance by aggregating several factors including investment methodology, returns, fees, administration and governance/risk framework. A total of seventeen of these funds (representing the top 15 per cent of their universe) received the highest or 'platinum' rating. In this paper, we limit our study to these 'platinum' rated funds since most of these funds can be expected to have default investment strategies that are relatively well designed compared to those of funds with lower ratings. The asset allocation data for individual default investment strategies is collected from the product disclosure statements available in the respective websites of these funds as on March 2006.

[8] More details of the survey and rankings are available on SuperRating's website, www.superratings.com.au

Use of lifecycle funds as default options in DC plans has been gaining popularity in recent years (Feinberg, 2004). However, most Australian superannuation funds continue to offer static fixed weight allocation strategies as investment options to members. In our study, only three of the seventeen default investment options change their allocation with the age of the participant. But unlike typical 'target retirement funds' in the US and elsewhere where the benchmark asset allocation is changed continuously and gradually to achieve a more conservative asset allocation as the members grow older and approach retirement, the change in asset allocation here is done instantaneously when the members reach specified age threshold(s). For each of these three default options, we examine two different allocation rules: one assuming that their initial asset allocation remains unchanged till the retirement of the participant (which is equivalent to a fixed weight strategy) and another following the exact switch in allocations given by the actual default option i.e. lifecycle strategy. This enables us to directly compare the results and determine whether this type of lifecycle strategies can be expected to produce superior outcomes for the participants, particularly in terms of reducing risk. In addition, we examine two hypothetical strategies: (i) default option average (DOA) strategy whose allocation is same as the average allocation of default options for all Australian superannuation funds as of June 2004; and, (ii) the 100 per cent stocks strategy.

Initially we conduct our analysis under the assumption that the DC plan assets are invested in Australian stocks, bonds, and bills. Allocations of the default options to international stocks and international bonds are, therefore, included in domestic stocks and bonds respectively. We, later, repeat the simulations by including international stocks and international bonds as separate asset classes but do not present the results here since these lead to very similar conclusions.[9] Although 'property' is an important asset class for investment by these funds, we do not include it as a separate asset class in our analysis because of the paucity of reliable long-term return data. Similarly 'alternative investments' which mainly comprises of investments in infrastructure, hedge funds, and commodities, cannot be included because of the lack of specific information on their composition and therefore of any reliable index to measure returns. While examining investment strategies of Australian superannuation funds, we handle their allocation component to 'properties' and 'alternative investments' in a manner similar to that of other well-known studies like Brinson et. al., (1986) and Arshanapalli, Coggin, and Nelson

[9] This may be due to the reason that we use US stocks and US bonds, which are highly correlated with their Australian counterparts, as proxies for international stocks and international bonds.

(2001), where the percentage allotted to 'others' is divided between equities, bonds and bills on a pro-rata basis. However, we choose to direct the allocations against 'property' and 'alternative investments' only to equities and bonds (and not bills) on a pro-rata basis, because we believe that the risk-return profile of these asset classes is far removed from that of bills (cash). The asset allocation data for every strategy included in our analysis are provided in Table I.

[INSERT TABLE I ABOUT HERE]

Out of the seventeen 'platinum' rated funds used in our analysis, eight funds have their default option's initial allocation to stocks ranging between 60% and 70% which typically represents a balanced diversified fund. The DOA strategy also has an asset allocation profile similar to these strategies. Of the remaining funds, four funds have their default strategy's initial allocation to stocks between 70% and 80% while the default strategies of other five funds are highly aggressive with more than 80% of assets invested to stocks. Only three of the default strategies (#18, #19, and #20) change their initial asset allocation with the age of the member. To examine the efficacy of these lifecycle strategies, we devise three corresponding fixed weight strategies (#6, #7, and #16) by assuming that their initial asset allocations remain constant throughout the investment horizon. Therefore, we have seventeen fixed weight strategies (fourteen actual and three devised), three lifecycle strategies, and two hypothetical strategies, that is, twenty-two strategies in total available for our analysis.

IV. Simulation Experiments and Results

Based on the wealth accumulation model described in Section II, we simulate RWR outcome for all the twenty-two asset allocation strategies. We conduct two separate sets of simulation experiments using the Monte Carlo and bootstrap resampling methods for return generation respectively. For both sets of experiments, we conduct 5,000 iterations for every asset allocation strategy under consideration to generate 5,000 different investment return paths over 40-year periods. These simulated returns are applied every year on corresponding cash flows in the participant's account to produce a range of 5,000 RWR outcomes under every strategy at the end of the 40-year horizon. Each set of experiment is initially conducted based on historical asset class returns for the entire period of availability of data, 1900 through 2004. However, it is quite possible that structural changes in the domestic and the international economy may render data from very distant past, especially before the Second World War, less relevant in projecting future asset class returns. Therefore, we repeat the simulations using two more recent datasets: one for the entire post-war period (1947-2004) and another for the most recent 30 year period (1975-2004). Since the estimates obtained by the Monte Carlo and the bootstrap resampling experiments are very similar, we report only the results of the former in Tables II, III, and IV.[10]

We set the wealth accumulation target RWR_T for the plan participant at 8.0 i.e. 800 per cent of salary at retirement. Booth and Yakoubov (2000) uses a target wealth of 500 per cent of salary at retirement which translates into a RWR_T of 5.0. Although there is no consensus on what can be considered as an adequate wealth to income ratio for Australian retirees, we choose to set RWR_T at a seemingly higher level for two reasons. First, several commentators consider the current wealth to income levels as grossly inadequate in view of increasing life expectancy and growing health care costs. Second, since our study ignores the taxes on retirement savings and investment returns as well as transaction costs while modelling terminal wealth outcomes, we feel the need to compensate it by setting the target wealth outcome on the higher side. However, setting RWR_T at a different value is not expected to alter the relative ranking of asset allocation strategies as long as we hold it constant for all the simulations.

A. RWR Distribution

The distribution of RWR for each asset allocation strategy provides us with the range of wealth outcomes the participant may expect to confront at the point of retirement. In addition to mean and median RWR, we estimate the first and third quartile estimates of the distribution for every allocation strategy to assess their relative appeal. For any of these parameters, a higher value would generally make a strategy more attractive. Table II provides the distribution parameters of RWR for each of the asset allocation strategies. The results indicate that RWR varies significantly across asset allocation strategies. The mean and the median RWR seem to increase for strategies with higher allocation to stocks and are highest for the strategy which invests entirely in stocks. The median RWR for the *100 per cent stocks* strategy is over 50 per cent higher than that of DOA strategy, which only has two-thirds of assets invested in stocks. Although in a few cases, the mean and median RWR are not higher for the strategy with higher proportion of stocks, we find that the allocations to stocks in these cases are very close, and the difference in outcome seems to be more influenced by the difference in their allocation

[10] Results of the bootstrap resampling experiments can be obtained by contacting the authors.

splits between bonds and cash.

[INSERT TABLE II ABOUT HERE]

The first and third quartile outcomes also tend to increase as we move from strategies with lower proportion of stocks to those with higher proportion of stocks. The difference between first quartile outcomes of different strategies are relatively smaller compared to the spread between the third quartile outcomes. For example, the first quartile outcomes for the strategy with the lowest and highest allocation to stocks are 5.70 and 7.48 respectively. The corresponding estimates for their third quartile outcomes are 12.04 and 19.02. Again, the *100 per cent stocks* strategy results in the best first and third quartile RWR outcomes. The increasing trend in RWR outcomes with aggressiveness of the asset allocation strategy is graphically demonstrated in Figure 1. Generally more aggressive is the strategy, higher (lower) is the maximum (minimum) RWR outcome. Also, the minimum outcomes for different strategies lie within a narrow range (0.57 to 1.13) which shows that there is not much to choose between the strategies on the basis of their worst outcomes.

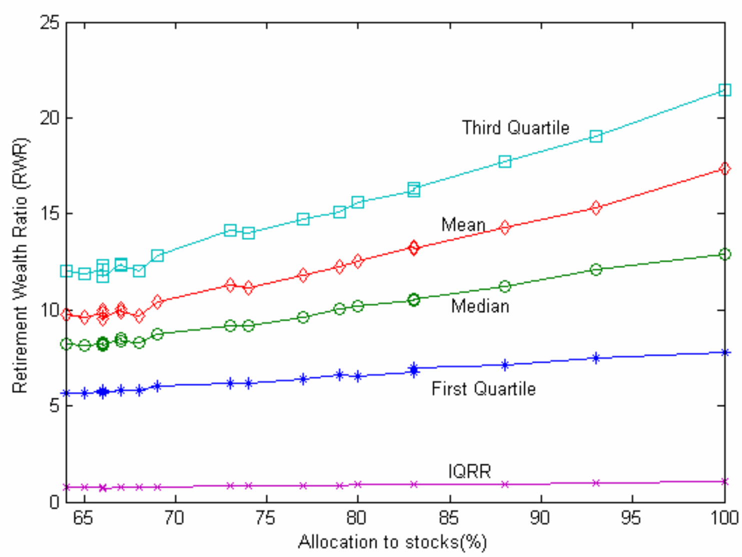

Figure 1. RWR distribution parameters for simulation using full period (1900-2004) data. IQRR denotes the interquartile range ratio which is used as a measure of dispersion of RWR outcomes. RWR distribution parameters for lifecycle strategies are not included since these have changing allocation to stocks over time.

The results of Monte Carlo simulations using returns data for 1947-2004 and 1975-2004 give similar indications about the effect of asset allocation strategies on terminal wealth outcomes. While the RWR estimates for various strategies vary when we use data for different periods, strategies with higher allocations to stocks consistently dominate those with lower allocation to stocks in terms of mean, median, first quartile, and third quartile outcomes. As before, the *100 per cent stocks* strategy result in the best outcomes for all these parameters except the first quartile outcome for the simulations using 1975-2004 data. The best result, in this case, is produced by a strategy which invests 88 per cent of assets in stocks and remaining in bonds.

Our simulations produce a range of possible RWR outcomes for every strategy. It is important to measure the dispersion of RWR outcomes for each strategy in order to form a view on possible future retirement wealth disparity among different cohorts following that strategy. The estimates for both CV and IQRR indicate that the dispersion of RWR outcomes tends to increase with increase in allocation to stocks although the rate of increase seems to be very small. For instance, the IQRR for the strategy with lowest stock allocation (64%) is 0.7725 while that for the strategy with highest allocation to stocks (93%) is 0.9559. The hypothetical 100 per cent stocks strategy produces an IQRR of 1.0631. These estimates indicate that the disparity in wealth outcomes between the cohorts who meet very positive investment return scenarios and those who confront relatively unfavourable investment returns during their employment life while being enrolled in the same default option may be dependent on the allocation policy of the plan. Nevertheless, the difference in disparity across cohorts for strategies with different proportions of stocks may no be very large. This is well demonstrated by the flatness of the IQRR curve when plotted against strategies with changing allocation to stocks. The simulation results using data for recent periods also support these findings.

By comparing the RWR distribution parameters of each of the lifecycle strategies (#18, #19, and #20) with those of the corresponding strategy that maintains its initial asset class weighting (#6, #7, and #16 respectively), we find that former produces lower mean, median, first quartile, and third quartile outcomes in every case. Yet the minimum outcome in almost all cases is slightly higher for the lifecycle strategies.[11] Since the CV and IQRR are also always lower for lifecycle strategies, it seems that switching to a conservative allocation as the employee approaches retirement may actually reduce the dispersion in RWR outcomes. In other words, if these strategies do not switch their asset allocation with the members approaching retirement, the range of expected wealth outcomes gets wider.

B. Downside Risk and Risk-Adjusted Performance Estimates

We use lower partial moments with risk aversion parameters 0, 1, and 2 so that the investors with different levels of risk tolerance can use these estimates to evaluate alternative asset allocation strategies. Table III reports the downside risk estimates for RWR under different asset allocation strategies.

[INSERT TABLE III ABOUT HERE]

Estimates for all the *LPM* measures steadily increase with decrease in allocation to stocks indicating a clear inverse relationship. For instance, the LPM_0 for the strategy with 64 per cent allocation to stocks is 0.4826 which indicates that there is a 48.26 per cent probability that the RWR would fall below RWR_T (close to the toss of a fair coin). In comparison, the probability of shortfall for the strategy with 77% stocks is 38.58 per cent and for the strategy with 93 per cent stocks is 28.06 per cent. Interestingly, the 100 per cent stocks strategy has only 26.22 per cent, or around one-in-four, probability of falling below RWR_T , which is the lowest of all strategies, while DOA strategy has almost 47 per cent chance of underperforming that target.

Similar trends are also observed for measures of magnitude of shortfall (LPM_1) and below target semivariance (LPM_2) indicating that the downside risk actually gets reduced by of increasing allocation to stocks in the portfolio. Figure 2 graphically depicts this trend. The slopes of LPM curves reveal that the rate of decline of downside risk gets higher with increasing risk aversion, that is, more averse the participants are to the downside risk of failing to meet their wealth accumulation objective, more appealing would the aggressive strategies be relative to balanced or conservative strategies.

[11] However, the minimum outcome may not serve as a useful evaluation criterion because there is only a 1 in 5,000 chance of getting that outcome.

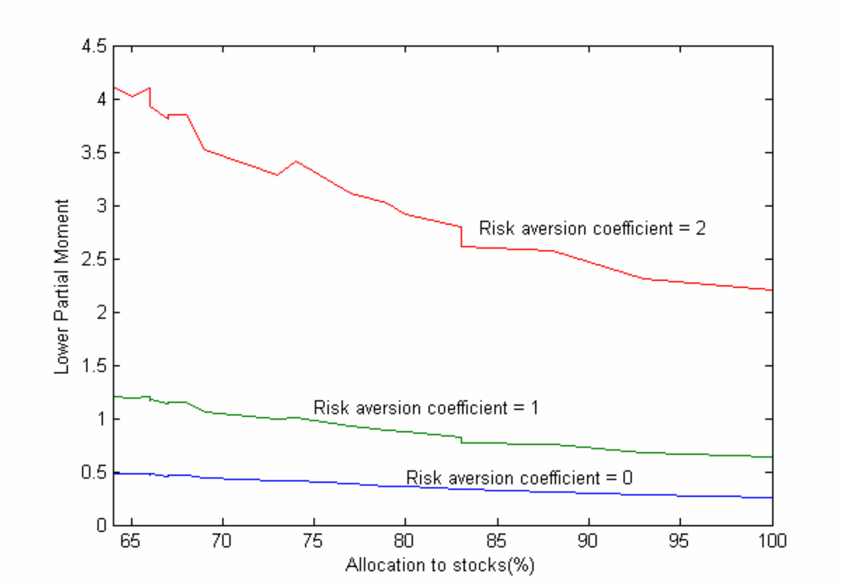

Figure 2. Downside risk estimates for simulation using full period (1900-2004) data. Lower partial moments for *RWR* outcomes have been computed for three different degrees of risk aversion: 0, 1, and 2. RWR_T is set at 8.0. Lifecycle strategies are not included since these have changing allocation to stocks over time.

Simulation results using post-war data also suggest that *LPM* estimates are generally smaller for strategies with higher allocation to stocks. However, the results are not as conclusive when we use recent 30-year returns data as simulation input. While the LPM_0 estimates are still lower for more aggressive strategies, albeit by a much smaller margin, this is not true for LPM_1 and LPM_2. The estimates for LPM_1 do not exhibit any clear trend with similar estimates observed for strategies with significantly different proportion of stocks. For LPM_2, the estimates are generally lower for strategies holding lower proportion of stocks. The evidence for lifecycle strategies also follows the same pattern. The simulation results using full period and post-war period data shows that the downside risk actually increases by making lifecycle switching whereas results with the recent 30-year returns data indicates mixed trends - LPM_0 estimates are higher (higher downside risk) while LPM_1 and LPM_2 estimates are lower (suggesting lower downside risk) for lifecycle strategies compared to corresponding strategies where the initial asset weightings remain unchanged.

While the terminal wealth outcomes and associated risks involved with each allocation strategy under consideration can be assessed from the parameters of the simulated RWR distribution and various measures of LPM, composite performance measures are essential to rank the strategies based on overall risk-reward profile. We compute estimates for Sortino and UPR, performance measures that are adjusted for downside risk and also produce these results in Table III. For simulations using full period data, Sortino and UPR are generally found to increase with rising proportion of stocks in the strategy. This is almost always the case with strategies with more than 70% allocation to stocks. The 100% stock strategy results in the highest Sortino and UPR.

The above results come as no surprise since we earlier found strategies with higher stock allocation to be superior in terms of terminal wealth outcomes as well as downside risk based on our simulation with the full period data. Of more interest is the performance estimates for simulations using data for the other two sub-periods because downside risk estimates in these cases lead to conclusions that were different from those of simulation with the full period data, particularly for LPM_1 and LPM_2. However, we find that the risk-adjusted performance estimates for the sub-periods are supportive of the rankings indicated by the full-period simulation. Estimates for both Sortino and UPR in these cases indicate that an allocation rule dominated by stocks result in better risk adjusted performance and therefore, are consistent with the findings based on simulation using full period data. Also, lifecycle strategies produce inferior risk-adjusted performance estimates in all cases compared to their fixed weight counterparts.

C. Tail-Related Risk Estimates

As discussed in Section I, it is plausible that plan participants may care more about the most adverse outcomes that can occur for a given strategy which makes it important to analyse the risk of these extreme events. Plan providers in that case are likely to use 'maxi-min' rule to select a strategy which maximizes the worst '*n'* percentile of outcomes. In this paper, we estimate VaR and ETL at 95 per cent confidence level, which means we assume that the participants are concerned about the worst 5 per cent of RWR outcomes. While it is theoretically possible that some participants may demonstrate an even greater degree of risk aversion, that is, they may only consider RWR outcomes that are below an even lower threshold (say 1 per cent), we believe that in reality the 5th percentile outcome would serve as an adequate indicator of extreme risk for majority of participants. Moreover, for participants who are concerned about outcomes falling below 5th percentile, the ETL measure provides the expected value of such outcome.

The results for VaR and ETL estimates are produced in Table IV. The results for simulations using full period data indicate that the VaR estimates, in general, tend to increase with aggressiveness of the asset allocation strategy although strategies with higher proportion of stocks do not always result in better outcome than a strategy with slightly lower proportion of stocks. More importantly, it is observed that the difference among the VaR estimates of different asset allocation strategies is very small.

[INSERT TABLE IV ABOUT HERE]

The lowest observed VaR estimate is 3.3936 given by the strategy with lowest allocation to stocks which means employing this by strategy there is a 5 per cent (or one-in-twenty) chance of the RWR falling below that level. The highest VaR estimate (4.0033) is produced by the 100 per cent stock strategy which goes against the conventional logic that stocks, being most volatile among the asset classes, can potentially result in the most adverse outcomes. The results for ETL also support these conclusions.

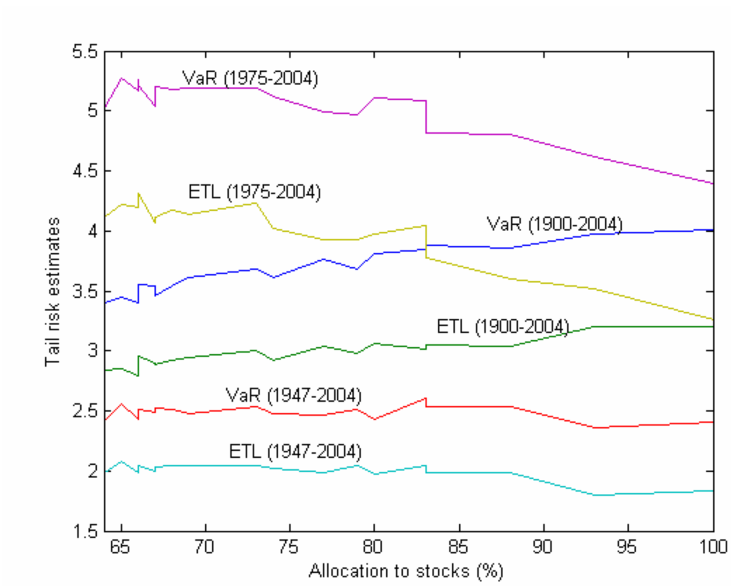

Figure 3. Tail risk estimates of asset allocation strategies at 95 per cent confidence level for simulations using asset class returns data for full period (1900-2004), post-war period (1947-2004), and most recent 30-year period (1975-2004). Lifecycle strategies are not included since these have changing allocation to stocks over time.

The simulation results based on data for other periods present a slightly different picture but do not alter the fundamental conclusion of the previous simulation. Using data for 1947-2004 period, the VaR estimates of individual strategies are found to lie within a very close range (2.3603-2.6014) and do not seem to follow any clear pattern. The 100 per cent stocks strategy produces a VaR estimate of 2.41

which is almost same as that of the strategy with the lowest stock allocation (64 per cent) but slightly lower than that of DOA strategy which has 67 per cent allocation to stocks and produces a VaR estimate of 2.5196. Similarly, the ETL estimates are generally higher for the balanced strategies but only marginally, as with VaR estimates.

Simulation with data for 1975-2004 period results in higher VaR and ETL estimates for balanced strategies compared to the more aggressive strategies. Generally, VaR and ETL estimates seem to gradually deteriorate with increasing stock allocation. This is quite the opposite of our results using 1900-2004 data but the range of VaR estimates is still very narrow. The lowest estimate of 4.3970 is given by the 100 per cent stocks strategy, which means that the participants who invest in this strategy have a 5 per cent chance of accumulating wealth that is less than 4.39 times their final annual salary. The highest estimate of 5.4205 is produced by lifecycle strategy #18 which invests two-thirds in stocks for participants below 60 years and one-third thereafter. By adopting this strategy, participants would have a 5 per cent chance of having their plan account balance at retirement less than 5.42 times their final annual salary. It is easy to see that the gap between these two situations can hardly be considered as the difference between a ruinous and a non-ruinous outcome. This is confirmed by the ETL estimates which range from 3.2636 to 4.5456 indicating even the below 5 per cent outcomes are not very different between different allocation strategies. Thus our evidence clearly implies that the risk of confronting extremely poor retirement wealth outcomes may not be very sensitive to the choice of asset allocation strategy.

The evidence on the most adverse outcomes for lifecycle strategies and their corresponding fixed weight strategies is mixed. While simulations using data for the full period and the post-war period result in lower VaR estimates for lifecycle strategies compared to corresponding fixed weight strategies, the results are quite the opposite for simulations based on the most recent 30 year period (1975-2004) when all three lifecycle strategies are found to slightly improve the VaR estimates. The ETL estimates also follow the same pattern except for simulations with post war data where two of the three lifecycle strategies produce higher estimates than their corresponding fixed weight strategies. Based on this evidence, the claim of lifecycle strategies reducing the risk of most unfavourable outcomes does not appear to be strong. Even in cases where they reduce the severity of the extreme outcomes, the benefits appear to be marginal.

V. Conclusion

Given the fact that Australian stocks have significantly outperformed fixed income securities over long horizons in the past, it is no surprise that differences between default investment options with respect to their exposure to stocks result in large differences in simulated terminal wealth outcomes for DC plan participants. More revealing is our finding that very high allocations to stocks may actually prove to be less risky on most occasions if risk is viewed in the context of falling short of the participant's wealth accumulation target, in terms of both probability and magnitude of shortfall.

At present, regulators in most countries, including Australia, do not prescribe any asset allocation structure for default investment options. But very often they emphasise the importance of diversification in coping with risk by optimizing its trade-off with returns. Our results, however, raise serious questions about the benefits of diversification for very long term investors like DC plan participants, who seem to have higher likelihood of being better off by concentrating their investments in stocks alone. We have demonstrated that the strategies that are heavily tilted towards stocks not only reduce the chance of failure in meeting the participants' wealth accumulation target but also seem to diminish the extent of shortfall in case the participants fail to achieve such objective. At the same time, they seem to offer strong upside potential of generating terminal wealth outcomes that outperform the participant's accumulation target at retirement.

Perhaps the most powerful evidence against selecting balanced diversified strategies or even moderately aggressive strategies as default options is provided by our results for tail-related risk. As stock returns are essentially considered to be more volatile than other asset class returns, one would have normally expected their presence in the portfolio to cause more extreme outcomes. However, our results indicate that the extreme wealth outcomes occur mostly at the upper tail of the wealth distribution, which is actually favourable to the plan participant. The measures for the extreme outcomes at the lower tail of retirement wealth distribution suggest that higher allocation to stocks do not necessarily increase the risk of confronting these adverse outcomes and in some cases, may even reduce their severity. In our study, the risk of extremely adverse outcome does not seem to vary considerably with change of asset allocation which implies that extreme loss aversion should have minimal role to play in asset allocation decision for default investment options.

Trustees using conservative or balanced diversified strategies as defaults may argue that these strategies tend to reduce the variability of outcomes and therefore can potentially minimize the problems associated with disparity in wealth accumulated by different employee cohorts. But selection of defaults primarily on this criterion can be deemed as flawed given that the trade-off involves much lower accumulation of retirement wealth and therefore, defeats the very purpose of instituting these plans. By nominating such 'safe' strategies as defaults, plan providers may actually be instrumental in creating future generations of retirees who are 'more equal' but 'poorer' instead of retiree cohorts who are 'less equal' but nevertheless 'wealthier'. This is also the case with the lifecycle strategies considered in our study which reduce the variability of wealth outcomes but at the cost of producing much lower retirement wealth than what the participants could potentially achieve by not switching to a relatively conservative allocation rule as they near retirement.

Shiller (2003) opines that merely defining and implementing the default option correctly for individual accounts within social security can prove to be the most effective tool for intervention. It appears that the same also applies to individual accounts in DC plans. This paper strongly suggests the possibility of widely different wealth outcomes confronting many DC plan participants simply as a result of the existing disparity in asset allocation structure between their plans' default investment options. It demonstrates that the balanced diversified strategies nominated by many plan providers in Australia as default investment options may not be well suited to optimise the retirement benefits of the participants. The problem may be even more serious for countries like the US, where DC plans typically adopt an even more conservative approach towards asset allocation.

Two issues related to our study deserve further attention. First, our results, undoubtedly, have been influenced by the large premium that Australian stocks have enjoyed historically over bonds and bills. By using long term return data for asset classes over a hundred years, we have attempted to ensure that our results are not biased by returns for any asset class in a particularly favourable (or unfavourable) period. Yet, as many commentators have observed, even a century long dataset may be inadequate to predict the entire gamut of future possibilities. Analysing the impact of potential fall in real equity premium in future on the appropriateness of default investment choice in DC plans can be an area which future research would do well to investigate. Second, our investigation has been limited to static asset allocation strategies that are currently favoured by DC plan providers. However, to consider the optimality of a strategy among all available options, it is essential to consider a range of dynamic allocation strategies from those which would alter portfolio weights in response to time varying equity premium to ones which would allocate dynamically based on accumulation of retirement assets at any point relative to a set target.

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Table I: Asset Allocation of Default Investment Options

	Stocks (%)	Bonds (%)	Cash (%)
FIXED WEIGHT STRATEGIES			
1. UniSuper Balanced	64	36	0
2. Equipsuper Balanced Growth	65	30	5
3. HOSTPlus Balanced	66	32	2
4. Sunsuper Balanced	66	32	2
5. REST Core	66	24	10
6. Telstra Balanced*	67	33	0
7. First State Super Diversified#	68	17	15
8. CARE Super Balanced	69	26	5
9. Westcheme Trustee's Selection	73	27	0
10. Vision Balanced Growth	74	23	3
11. HESTA Core Pool	77	21	2
12. NGS Diversified	79	18	3
13. ARF Balanced	80	18	2
14. STA Balanced	83	15	2
15. Cbus Super	83	14	3
16. Health Long Term Growth^	88	12	0
17. MTAA	93	4	3
LIFECYCLE STRATEGIES			
18. Telstra:			
Under 60 years (Balanced)	67	33	0
60 years and above (Conservative)	32	48	20
19. First State Super:			
Up to 56 years (Diversified)	68	17	15
Above 56 years (Balanced)	47	28	25
20. Health:			
Less than 50 years (Long Term Grow.)	88	12	0
50 to 60 years (Medium Term Growth)	64	36	0
Above 60 years (Balanced)	41	59	0
HYPOTHETICAL STRATEGIES			
21. Default Option Average	**67**	**26**	**7**
22. 100% Stock	**100**	**0**	**0**

* Initial allocation of lifecycle strategy #18; # Initial allocation of lifecycle strategy #19; ^ Initial allocation of lifecycle strategy #20

Table II: Distribution Parameters of Retirement Wealth Ratio (RWR)

Table II reports the distribution of RWR from the Monte Carlo simulation (multivariate normal). A total of 5,000 iterations for every asset allocation strategy under consideration to generate different investment return paths over 40-year periods. Max., Min., Q1, and Q3 denote maximum, minimum, first quartile, and third quartile RWR outcomes respectively. CV and IQRR measure the dispersion of RWR outcomes and stands for coefficient of variation and interquartile range ratio for the distribution of RWR outcomes respectively.

PANEL A: SIMULATION RESULTS BASED ON 1900-2004 DATA								
	Mean	Median	Max.	Min.	Q1	Q3	CV	IQRR
FIXED WEIGHT STRATEGIES								
1. UniSuper Balanced	9.73	8.21	75.73	1.19	5.70	12.05	0.62	0.77
2. Equipsuper Bal. Growth	9.61	8.16	82.63	1.46	5.69	11.90	0.60	0.76
3. HOSTPlus Balanced	9.85	8.24	73.28	1.44	5.72	12.10	0.64	0.77
4. Sunsuper Balanced	9.98	8.33	99.95	1.50	5.84	12.34	0.63	0.78
5. REST Core	9.56	8.17	74.64	1.56	5.70	11.70	0.60	0.73
6. Telstra Balanced	10.06	8.54	82.95	1.44	5.83	12.36	0.65	0.76
7. First State Super Div.	9.70	8.33	66.52	1.17	5.82	12.05	0.59	0.75
8. CARE Super Balanced	10.43	8.77	93.14	1.25	6.06	12.84	0.64	0.77
9. Westscheme Trustee's Sel.	11.32	9.19	98.41	1.27	6.18	14.15	0.69	0.87
10. Vision Balanced Growth	11.12	9.14	67.29	1.33	6.20	14.02	0.65	0.86
11. HESTA Core Pool	11.83	9.61	89.89	1.26	6.38	14.72	0.69	0.87
12. NGS Diversified	12.24	10.03	115.97	1.19	6.58	15.13	0.72	0.85
13. ARF Balanced	12.54	10.17	153.85	1.32	6.55	15.58	0.72	0.89
14. STA Balanced	13.24	10.50	133.49	1.31	6.76	16.22	0.77	0.90
15. Cbus Super	13.16	10.57	114.17	1.47	7.00	16.37	0.73	0.89
16. Health Long Term Growth	14.31	11.24	136.11	1.28	7.12	17.71	0.74	0.94
17. MTAA	15.28	12.07	108.19	1.50	7.49	19.03	0.78	0.96
LIFECYCLE STRATEGIES								
18. Telstra	9.02	7.78	49.18	1.56	5.46	11.12	0.58	0.73
19. First State Super	8.64	7.56	47.90	1.31	5.40	10.66	0.54	0.70
20. Health	9.47	8.12	65.26	1.49	5.66	11.54	0.61	0.72
HYPOTHETICAL STRATEGIES								
21. Default Option Average	**9.90**	**8.37**	**72.27**	**1.69**	**5.84**	**12.34**	**0.62**	**0.78**
22. 100% Stock	**17.37**	**12.88**	**194.55**	**1.13**	**7.78**	**21.48**	**0.90**	**1.06**

Table II (cont'd): Distribution Parameters of Retirement Wealth Ratio (RWR)

	Mean	Median	Max.	Min.	Q1	Q3	CV	IQRR
PANEL B: SIMULATION RESULTS BASED ON 1947-2004 DATA								
FIXED WEIGHT STRATEGIES								
1. UniSuper Balanced	7.53	6.11	122.60	1.14	4.13	9.19	0.74	0.83
2. Equipsuper Bal. Growth	7.53	6.14	56.56	0.77	4.17	9.30	0.68	0.84
3. HOSTPlus Balanced	7.75	6.32	70.14	0.90	4.14	9.52	0.71	0.85
4. Sunsuper Balanced	7.73	6.28	114.36	0.90	4.17	9.55	0.73	0.86
5. REST Core	7.80	6.45	47.83	1.02	4.30	9.66	0.67	0.83
6. Telstra Balanced	7.83	6.33	73.43	0.97	4.20	9.59	0.73	0.85
7. First State Super Div.	7.88	6.45	67.46	0.88	4.34	9.67	0.69	0.82
8. CARE Super Balanced	8.01	6.45	66.90	0.88	4.30	9.77	0.72	0.85
9. Westscheme Trustee's Sel.	8.90	6.90	77.26	0.97	4.53	11.05	0.79	0.95
10. Vision Balanced Growth	8.86	6.86	159.40	0.98	4.52	10.94	0.83	0.94
11. HESTA Core Pool	9.15	7.11	87.00	0.75	4.45	11.45	0.81	0.98
12. NGS Diversified	9.43	7.06	82.73	0.90	4.53	11.81	0.82	1.03
13. ARF Balanced	9.47	7.25	87.65	0.94	4.58	11.50	0.84	0.95
14. STA Balanced	10.58	7.57	269.15	0.87	4.76	12.69	1.08	1.05
15. Cbus Super	10.49	7.71	210.27	0.76	4.69	12.78	0.93	1.05
16. Health Long Term Growth	11.26	8.14	167.64	0.58	4.83	13.72	0.96	1.09
17. MTAA	12.01	8.38	165.10	0.57	4.90	14.64	0.99	1.16
LIFECYCLE STRATEGIES								
18. Telstra	6.92	5.78	60.38	0.79	4.01	8.53	0.63	0.78
19. First State Super	7.03	5.87	59.13	1.15	4.07	8.53	0.65	0.76
20. Health	7.44	6.07	47.68	0.88	4.13	9.15	0.68	0.83
HYPOTHETICAL STRATEGIES								
21. Default Option Average	**7.77**	**6.31**	**87.21**	**0.99**	**4.29**	**9.49**	**0.71**	**0.82**
22. 100% Stock	**13.63**	**8.92**	**228.03**	**0.76**	**5.11**	**16.54**	**1.14**	**1.28**

Table II (cont'd): Distribution Parameters of Retirement Wealth Ratio (RWR)

PANEL C: SIMULATION RESULTS BASED ON 1975-2004 DATA	Mean	Median	Max.	Min.	Q1	Q3	CV	IQRR
FIXED WEIGHT STRATEGIES								
1. UniSuper Balanced	15.99	13.29	115.88	1.41	8.88	19.85	0.68	0.83
2. Equipsuper Bal. Growth	16.21	13.36	135.89	1.82	9.05	19.80	0.68	0.80
3. HOSTPlus Balanced	16.82	13.64	131.48	1.90	9.24	20.75	0.69	0.84
4. Sunsuper Balanced	16.88	13.90	154.42	1.90	9.26	21.21	0.69	0.86
5. REST Core	15.81	13.15	149.30	2.25	8.91	19.76	0.66	0.82
6. Telstra Balanced	16.57	13.69	173.81	1.87	9.08	20.54	0.69	0.84
7. First State Super Div.	15.92	13.24	161.27	1.61	8.87	19.88	0.66	0.83
8. CARE Super Balanced	17.18	13.75	147.68	1.69	9.04	21.70	0.73	0.92
9. Westscheme Trustee's Sel.	18.52	14.55	148.00	1.74	9.52	22.77	0.76	0.91
10. Vision Balanced Growth	18.81	14.96	197.04	1.44	9.51	23.22	0.77	0.92
11. HESTA Core Pool	19.49	15.05	223.53	1.31	9.61	23.93	0.84	0.95
12. NGS Diversified	20.33	15.79	430.06	1.42	9.76	25.42	0.85	0.99
13. ARF Balanced	20.47	15.64	331.79	1.39	9.73	25.57	0.86	1.01
14. STA Balanced	21.31	15.96	278.44	1.70	9.94	26.65	0.85	1.05
15. Cbus Super	21.91	16.03	276.49	1.47	9.89	26.91	0.90	1.06
16. Health Long Term Growth	23.67	17.11	375.28	1.01	9.97	29.19	0.95	1.12
17. MTAA	24.88	17.34	471.52	0.98	9.95	30.50	1.04	1.18
LIFECYCLE STRATEGIES								
18. Telstra	15.16	12.67	107.95	1.75	8.70	18.76	0.63	0.79
19. First State Super	14.64	12.45	146.95	2.27	8.71	17.83	0.63	0.73
20. Health	16.01	13.29	136.60	2.07	8.99	19.67	0.91	0.80
HYPOTHETICAL STRATEGIES								
21. Default Option Average	**16.32**	**13.42**	**130.57**	**1.71**	**8.97**	**20.40**	**0.68**	**0.85**
22. 100% Stock	**28.15**	**18.17**	**460.72**	**1.34**	**9.78**	**33.45**	**1.19**	**1.30**

Table III: Estimates for Downside Risk and Performance Measures

Table III reports estimates for downside risk and performance measures from the Monte Carlo simulation. LPM_O, LPM_1, and LPM_2 measure downside risk and represent lower partial moment with degree (λ) 0, 1, and 2 respectively. The downside risk adjusted performance measures SR and UPR denote Sortino ratio and upside potential ratio respectively. A target retirement wealth ratio (RWR_T) of 8.0 has been used in the simulations to estimate these measures.

Panel A: Simulation Results Based on 1900-2004 Data					
	LPM_0	LPM_1	LPM_2	SR	UPR
Fixed Weight Strategies					
1. UniSuper Balanced	0.4826	1.2058	4.1128	0.8544	1.4490
2. Equipsuper Balanced Growth	0.4864	1.1960	4.0210	0.8014	1.3978
3. HOSTPlus Balanced	0.4812	1.1992	4.0933	0.9149	1.5076
4. Sunsuper Balanced	0.4708	1.1609	3.9432	0.9979	1.5825
5. REST Core	0.4858	1.1813	3.9251	0.7862	1.3825
6. Telstra Balanced (Under 60)	0.4580	1.1329	3.8144	1.0571	1.6371
7. First State Super Div. (Up to 56)	0.4722	1.1514	3.8447	0.8673	1.4544
8. CARE Super Balanced	0.4384	1.0589	3.5243	1.2927	1.8567
9. Westscheme Trustee's Selection	0.4094	0.9874	3.2778	1.8359	2.3812
10. Vision Balanced Growth	0.4108	1.0025	3.4088	1.6925	2.2355
11. HESTA Core Pool	0.3858	0.9287	3.1060	2.1707	2.6977
12. NGS Diversified	0.3620	0.8855	3.0256	2.4365	2.9456
13. ARF Balanced	0.3554	0.8721	2.9170	2.6610	3.1716
14. STA Balanced	0.3408	0.8280	2.8008	3.1317	3.6264
15. Cbus Super	0.3302	0.7711	2.6087	3.1931	3.6705
16. Health LT Growth (Less than 50)	0.3132	0.7531	2.5702	3.9329	4.4027
17. MTAA	0.2806	0.6820	2.3084	4.7946	5.2435
Lifecycle Strategies					
18. Telstra	0.5194	1.3100	4.4336	0.4855	1.1076
19. First State Super	0.5438	1.3565	4.5678	0.3001	0.9348
20. Health	0.4868	1.2202	4.196	0.7189	1.3146
Hypothetical Strategies					
21. Default Option Average	**0.4696**	**1.1455**	**3.8546**	**0.9681**	**1.5516**
22. 100% Stock	**0.2622**	**0.6415**	**2.2062**	**6.3074**	**6.7393**

Table III (cont'd): Estimates for Downside Risk and Performance Measures

PANEL B: SIMULATION RESULTS BASED ON 1947-2004 DATA	LPM_0	LPM_1	LPM_2	SR	UPR
FIXED WEIGHT STRATEGIES					
1. UniSuper Balanced	0.6758	2.1418	8.6593	-0.1588	0.5690
2. Equipsuper Balanced Growth	0.6708	2.1008	8.3474	-0.1627	0.5644
3. HOSTPlus Balanced	0.6500	2.0645	8.4223	-0.0869	0.6244
4. Sunsuper Balanced	0.6520	2.0616	8.3608	-0.0927	0.6203
5. REST Core	0.6422	1.9866	7.9223	-0.0719	0.6339
6. Telstra Balanced (Under 60)	0.6508	2.0519	8.2799	-0.0606	0.6525
7. First State Super Div. (Up to 56)	0.6404	1.9645	7.8222	-0.0420	0.6604
8. CARE Super Balanced	0.6342	1.9842	7.9524	0.0034	0.7070
9. Westscheme Trustee's Selection	0.5854	1.8215	7.3011	0.3321	1.0062
10. Vision Balanced Growth	0.5904	1.8280	7.3254	0.3192	0.9946
11. HESTA Core Pool	0.5688	1.7991	7.3513	0.4231	1.0867
12. NGS Diversified	0.5644	1.7707	7.1433	0.5332	1.1957
13. ARF Balanced	0.5610	1.7444	7.1135	0.5523	1.2063
14. STA Balanced	0.5328	1.6290	6.5471	1.0092	1.6458
15. Cbus Super	0.5236	1.6430	6.7266	0.9618	1.5953
16. Health LT Growth (Less than 50)	0.4936	1.5611	6.4333	1.2868	1.9023
17. MTAA	0.4786	1.5407	6.5718	1.5652	2.1662
LIFECYCLE STRATEGIES					
18. Telstra	0.7112	2.2890	9.2494	-0.3543	0.3983
19. First State Super	0.7160	2.2379	8.8958	-0.3265	0.4239
20. Health	0.6768	2.1413	8.6017	-0.1900	0.5401
HYPOTHETICAL STRATEGIES					
21. Default Option Average	**0.6512**	**2.0240**	**8.0674**	**-0.0794**	**0.6333**
22. 100% Stock	**0.4494**	**1.4613**	**6.2095**	**2.2612**	**2.8477**

Table III (cont'd): Estimates for Downside Risk and Performance Measures

PANEL C: SIMULATION RESULTS BASED ON 1975-2004 DATA	LPM_0	LPM_1	LPM_2	SR	UPR
FIXED WEIGHT STRATEGIES					
1. UniSuper Balanced	0.1976	0.4018	1.1840	7.3444	7.7136
2. Equipsuper Balanced Growth	0.1846	0.3588	1.0403	8.0477	8.3995
3. HOSTPlus Balanced	0.1838	0.3705	1.0869	8.4585	8.8138
4. Sunsuper Balanced	0.1788	0.3502	1.0037	8.8621	9.2116
5. REST Core	0.1948	0.3725	1.0416	7.6533	8.0183
6. Telstra Balanced (Under 60)	0.1890	0.3810	1.1402	8.0291	8.3859
7. First State Super Div. (Up to 56)	0.1982	0.3824	1.1074	7.523	7.8864
8. CARE Super Balanced	0.1868	0.373	1.1027	8.7461	9.1013
9. Westscheme Trustee's Selection	0.1782	0.3543	1.0350	10.3392	10.6874
10. Vision Balanced Growth	0.1738	0.3691	1.1365	10.1426	10.4888
11. HESTA Core Pool	0.1768	0.3871	1.2170	10.419	10.7699
12. NGS Diversified	0.1734	0.3799	1.2054	11.2307	11.5767
13. ARF Balanced	0.1694	0.3691	1.1599	11.5822	11.9249
14. STA Balanced	0.1626	0.3547	1.1071	12.6542	12.9913
15. Cbus Super	0.1700	0.3774	1.2588	12.3981	12.7345
16. Health LT Growth (Less than 50)	0.1680	0.3949	1.3534	13.4668	13.8062
17. MTAA	0.1742	0.4319	1.5029	13.7728	14.1251
LIFECYCLE STRATEGIES					
18. Telstra	0.2038	0.3566	0.9211	7.4590	7.8306
19. First State Super	0.2014	0.3639	0.9836	6.6922	7.0592
20. Health	0.1876	0.3591	1.0184	7.9387	8.2945
HYPOTHETICAL STRATEGIES					
21. Default Option Average	**0.1868**	**0.3744**	**1.1073**	**7.9102**	**8.2659**
22. 100% Stock	**0.1812**	**0.4641**	**1.6793**	**15.551**	**15.9092**

Table IV: Tail Risk Estimates for RWR Distribution

Table IV reports tail risk estimates for the RWR Distribution from the Monte Carlo simulation. Value at Risk (VaR) and Expected Tail Loss (ETL) for RWR outcomes are estimated at 95% confidence level. Therefore, there is a 5% probability of the RWR falling below the VaR estimate. Conditional to the RWR falling below VaR i.e. for the worst 5% of RWR outcomes, the expected value is given by ETL.

PANEL A: SIMULATION RESULTS BASED ON 1900-2004 DATA		
	VaR	ETL
FIXED WEIGHT STRATEGIES		
1. UniSuper Balanced	3.3936	2.8416
2. Equipsuper Balanced Growth	3.4528	2.8546
3. HOSTPlus Balanced	3.3961	2.7940
4. Sunsuper Balanced	3.4546	2.8623
5. REST Core	3.5509	2.9596
6. Telstra Balanced (Under 60)	3.5407	2.8946
7. First State Super Diversified (Up to 56)	3.5439	2.9209
8. CARE Super Balanced	3.6079	2.9467
9. Westscheme Trustee's Selection	3.6781	3.0074
10. Vision Balanced Growth	3.6085	2.9194
11. HESTA Core Pool	3.7601	3.0432
12. NGS Diversified	3.6860	2.9813
13. ARF Balanced	3.8085	3.0626
14. STA Balanced	3.8493	3.0136
15. Cbus Super	3.8785	3.0489
16. Health Long Term Growth (Less than 50)	3.8527	3.0394
17. MTAA	3.9685	3.2016
LIFECYCLE STRATEGIES		
18. Telstra	3.3876	2.8527
19. First State Super	3.3596	2.8547
20. Health	3.4053	2.7809
HYPOTHETICAL STRATEGIES		
21. Default Option Average	**3.4616**	**2.8893**
22. 100% Stock	**4.0033**	**3.2043**

Table IV (cont'd): Tail Risk Estimates for RWR Distribution

PANEL B: SIMULATION RESULTS BASED ON 1947-2004 DATA	VaR	ETL
FIXED WEIGHT STRATEGIES		
1. UniSuper Balanced	2.4104	1.9786
2. Equipsuper Balanced Growth	2.5638	2.0846
3. HOSTPlus Balanced	2.4318	1.9809
4. Sunsuper Balanced	2.4679	2.0144
5. REST Core	2.5063	2.0462
6. Telstra Balanced (Under 60)	2.4900	2.0005
7. First State Super Diversified (Up to 56)	2.5059	2.0445
8. CARE Super Balanced	2.4761	2.0495
9. Westscheme Trustee's Selection	2.5348	2.0462
10. Vision Balanced Growth	2.4820	2.022
11. HESTA Core Pool	2.4687	1.9800
12. NGS Diversified	2.5171	2.0443
13. ARF Balanced	2.4241	1.9788
14. STA Balanced	2.6014	2.0458
15. Cbus Super	2.5400	1.9845
16. Health Long Term Growth (Less than 50)	2.5301	1.9845
17. MTAA	2.3603	1.7973
LIFECYCLE STRATEGIES		
18. Telstra	2.4083	2.0388
19. First State Super	2.4798	2.1051
20. Health	2.4494	1.973
HYPOTHETICAL STRATEGIES		
21. Default Option Average	**2.5196**	**2.028**
22. 100% Stock	**2.4100**	**1.8323**

Table IV (cont'd): Tail Risk Estimates for RWR Distribution

PANEL C: SIMULATION RESULTS BASED ON 1975-2004 DATA		
	VaR	ETL
FIXED WEIGHT STRATEGIES		
1. UniSuper Balanced	5.0125	4.1038
2. Equipsuper Balanced Growth	5.2719	4.2175
3. HOSTPlus Balanced	5.1698	4.1914
4. Sunsuper Balanced	5.2555	4.2777
5. REST Core	5.2100	4.3105
6. Telstra Balanced (Under 60)	5.0357	4.0709
7. First State Super Diversified (Up to 56)	5.1787	4.1742
8. CARE Super Balanced	5.1950	4.1339
9. Westscheme Trustee's Selection	5.1885	4.2363
10. Vision Balanced Growth	5.1203	4.0174
11. HESTA Core Pool	4.9902	3.9311
12. NGS Diversified	4.9661	3.9327
13. ARF Balanced	5.1072	3.9737
14. STA Balanced	5.0853	4.0408
15. Cbus Super	4.8199	3.7760
16. Health Long Term Growth (Less than 50)	4.8043	3.6031
17. MTAA	4.6138	3.512
LIFECYCLE STRATEGIES		
18. Telstra	5.4205	4.5456
19. First State Super	5.2575	4.3972
20. Health	5.2157	4.3255
HYPOTHETICAL STRATEGIES		
21. Default Option Average	**5.1974**	**4.1088**
22. 100% Stock	**4.3970**	**3.2636**

APPENDIX A: Descriptive Statistics of Historical Annual Return Data

1. **1900-2004 data**

	Stocks	Bonds	Bills
Mean	0.090952	0.022667	0.007238
Median	0.110000	0.020000	0.010000
Maximum	0.510000	0.620000	0.180000
Minimum	-0.380000	-0.270000	-0.160000
Standard Deviation	0.177426	0.133627	0.055131
Skewness	-0.247029	0.663710	-0.058101
Kurtosis	2.972500	6.086779	4.319608
Observations	105	105	105

2. **1947-2004 data**

	Stocks	Bonds	Bills
Mean	0.080517	0.010862	0.006207
Median	0.105000	0.020000	0.015000
Maximum	0.510000	0.270000	0.090000
Minimum	-0.380000	-0.270000	-0.160000
Standard Deviation	0.210642	0.114682	0.050881
Skewness	-0.140441	-0.464026	-0.988497
Kurtosis	2.416410	3.133224	4.467748
Observations	58	58	58

3. **1975-2004 data**

	Stocks	Bonds	Bills
Mean	0.109333	0.049667	0.032000
Median	0.115000	0.090000	0.030000
Maximum	0.510000	0.270000	0.090000
Minimum	-0.230000	-0.190000	-0.060000
Standard Deviation	0.205358	0.111308	0.037637
Skewness	0.084032	-0.414026	-0.588575
Kurtosis	2.081935	2.546260	3.133234
Observations	30	30	30

APPENDIX B: Correlation Matrices

1. **1900-2004 data**

	Stocks	Bonds	Bills
Stocks	1.0000	0.3389	0.2524
Bonds	0.3389	1.0000	0.6344
Bills	0.2524	0.6344	1.0000

2. **1947-2004 data**

	Stocks	Bonds	Bills
Stocks	1.0000	0.3237	0.2113
Bonds	0.3237	1.0000	0.6406
Bills	0.2113	0.6406	1.0000

3. **1975-2004 data**

	Stocks	Bonds	Bills
Stocks	1.0000	0.0542	-0.0671
Bonds	0.0542	1.0000	0.4207
Bills	-0.0671	0.4207	1.0000