DREW·WALK & CO

18 April 2016

Ms Yvette Goss
Superannuation
Productivity Commission
Locked Bag 2, Collins St East
Melbourne VIC 8003

Dear Ms Goss,

Re: *Submission - Superannuation Competitiveness and Efficiency*

Thank you for the opportunity to make a submission to the above Productivity Commission inquiry.

The attached ("Attachment 1") outlines a selection of our key research papers as they relate to a number of issues raised in the Terms of Reference.

Please do not hesitate to contact us if you would like to discuss this matter further.

Yours sincerely,

Prof Michael E. Drew
SFFin, FAIM, FGIA, FAICD, AIFA®
Director

Dr Adam N. Walk
SFFin, FGIA, FAICD, CIMA®, AIFA®
Director

Consulting Financial Economists

Suite 34, Ballow Chambers,
121 Wickham Terrace,
Spring Hill, Qld 4000

www.drewwalk.co
@DrewWalkCo

Drew, Walk & Co. Pty Ltd ACN 161 388 227 as agent for Drew, Walk Partnership ABN 86 466 323 308

Attachment 1

Retirement risk zone

- Basu, A, Doran B, and Drew, M 2012, *Sequencing Risk: A Key Challenge to Sustainable Retirement Incomes*, Finsia (Financial Services Institute of Australasia), Sydney.

- Drew, M, and Walk, A 2014, *How Safe are Safe Withdrawal Rates in Retirement? An Australian Perspective*, Finsia (Financial Services Institute of Australasia), Sydney.

- Drew, M, Walk A and West J 2015, The Role of Asset Allocation in Navigating the Retirement Risk Zone, Finsia (Financial Services Institute of Australasia), Sydney.

Outcome-oriented asset allocation

- Basu, A and Drew, M 2009, 'Portfolio Size and Lifecycle Asset Allocation in Pension Funds', *Journal of Portfolio Management*, vol. 35, no. 3, pp. 61-72.

- Basu, A, Byrne, A and Drew, M 2011, 'Dynamic lifecycle strategies for target date retirement funds', *Journal of Portfolio Management*, vol. 37, no. 2, pp. 83-96.

- Drew, M, Stoltz, P, Walk, A and West, J 2014, 'Retirement Adequacy through Higher Contributions: Is This the Only Way? *Journal of Retirement*, vol. 1, no.4, pp. 1-18.

Members at the centre of what we do

- Drew, M, Walk A and West J 2016, 'Withdrawal capacity in the face of expected and unexpected health and aged-care expenses during retirement.' *Journal of Retirement*, vol. 3, no. 3, pp. 77-94.

- Bianchi, R, Drew, M, Evans, M and Walk, A 2014, 'The Two Faces of Investment Performance and Risk', *JASSA: The Finsia Journal of Applied Finance*, no. 1, pp. 6-12.

- Bianchi, R, Drew, M and Walk, A 2013, 'The Time Diversification Puzzle: Why Trustees Should Care', *JASSA The Finsia Journal of Applied Finance*, no 1. pp. 51-55.

An electronic version of the *'Author's Copy'* of each of these papers has been provided as part of our submission.

Portfolio Size Effect in Retirement Accounts: *What Does It Imply for Lifecycle Asset Allocation Funds?*

ANUP K. BASU AND MICHAEL E. DREW

ANUP K. BASU
is a lecturer in the School of Economics and Finance at Queensland University of Technology in Brisbane, Australia.
a.basu@qut.edu.au

MICHAEL E. DREW
is a professor of finance in the Department of Accounting, Finance and Economics, Griffith University, in Brisbane, Australia.
michael.drew@griffith.edu.au

Lifecycle funds have gained great popularity in recent years. Sponsors of defined contribution (DC) plans offer more and more of these funds as investment options to plan participants. In many cases, these funds serve as default investment vehicles for plan participants who do not make any decisions about the investment of their plan contributions. As reported by Vanguard [2006], one of the largest pension plan managers in the U.S., two-thirds of their plans offered a lifecycle option in 2005, up from one-third in 2000. Assets in lifecycle funds amounted to $160 billion in 2005 compared to less than $10 billion in 1996 (Gordon and Stockton [2006]). The rapid growth of lifecycle investment programs within DC plans is often attributed to the fact that they simplify asset allocation choices for millions of ordinary investors who supposedly lack the knowledge or inclination to adjust their retirement portfolios over time.[1] For such an investor, the lifecycle fund offers an automatic "set it and forget it" solution by periodically modifying the asset allocation of retirement investments in line with the investor's diminishing capacity to bear risk.

The central theme of the lifecycle model of investing is that an investor's portfolio should become increasingly conservative as the investor ages (see, for example, Malkiel [2003]). In retirement plans, this is done by switching investments from more-volatile assets (e.g., stocks) to less-volatile assets (e.g., fixed-interest securities, such as bonds and cash equivalents) as the participant approaches retirement. For example, the Vanguard Target Retirement Funds prospectus states that

> [i]t is also important to realize that the asset allocation strategy you use today may not be appropriate as you move closer to retirement. The Target Retirement Funds are designed to provide you with a single Fund whose asset allocation changes over time as your investment horizon changes. Each Fund's asset allocation becomes more conservative as you approach retirement.

Although the lifecycle funds offered by different providers vary from one another with respect to how and when they switch assets, there is total unanimity about the overall direction of the switch—from stocks to bonds and cash.

The practitioner's common belief that an investor's exposure to risky assets should decrease with age (and the consequent shortening of the investment horizon) has been theoretically refuted by Samuelson [1963] and more recently by Bodie [1995], among others. There is no dearth, however, of published theoretical work that lends support to the popular view of practitioners (see, for example, Merrill and Thorley [1996] and Levy and Cohen [1998]). The relationship between horizons and investment risk has also been examined by empirical researchers resulting in different conclusions.[2] Much of the empirical work considers the case of a multi-period investor who invests in a portfolio of assets at the beginning of the first period and reinvests the original sum and the accumulated returns over several periods in the investment horizon.[3] The situation of retirement plan participants, however, is more complex, because they make additional, periodic investments in the form of plan contributions until their retirement. As a result, the plan participant's terminal wealth is determined not only by the strategic asset allocation governing investment returns, but also by the periodic contribution amounts that alter the size of the portfolio at different points on the horizon.

A recent observation by Shiller [2005a] harped on this issue, questioning the intuitive foundation of conventional lifecycle switching for investors' retirement plans. Shiller argued that

> a lifecycle plan that makes the percent allocated to stocks something akin to the privately offered lifecycle plans may do much worse than a 100% stocks portfolio since young people have relatively little income when compared to older workers.... The lifecycle portfolio would be heavily in the stock market (in the early years) only for a relatively small amount of money, and would pull most of the portfolio out of the stock market in the very years when earnings are highest.

The statement is remarkable in asserting that the portfolio size of a plan participant at different points in time is significant from an asset allocation perspective. If Shiller's assertion is true, then lifecycle funds may be missing a trick by ignoring the growing size of the participant's portfolio over time, while switching assets from stocks to fixed income or cash.

The size of the participant's retirement portfolio is likely to grow with time, not only because of possible growth in salary and the size of contributions, as Shiller indicates, but also due to the tax-free accumulation of plan contributions and the investment returns. In such a case, it would make little sense for the investor to follow the prescriptions of conventional lifecycle asset allocation. By moving away from stocks to low-return asset classes as the size of the retirement fund grows larger, the investor would be effectively foregoing the opportunity to earn higher returns on a larger sum of money invested.

But there is another side to this story. Advocates of lifecycle strategies point out that a severe downturn in the stock market at later stages of working life can have dangerous consequences for the financial health of a participant holding a stock-heavy retirement portfolio, not only because the market downturn can significantly erode the value of the investor's nest egg, but also because it leaves the participant with very little time to recover from the bad investment results. Lifecycle funds, by contrast, are specifically designed to preserve the nest egg of the graying investor. By gradually switching investments from stocks to less-volatile assets over time, lifecycle funds aim to lessen the chance of an investor confronting a very adverse investment outcome as he nears retirement.

In this article, we examine whether the lifecycle investment strategy benefits, or works against, the retirement plan participant's wealth accumulation goal, by reducing the allocation to stocks as the participant approaches retirement. We are particularly interested in testing whether the growing size of the accumulation portfolio in later years indeed calls for a higher allocation to stocks to produce better outcomes, despite the lurking danger of a sharp decline in stock prices close to retirement. Because an important objective of the lifecycle strategy is to avoid the most disastrous outcomes coincident with retirement, we assess its efficacy as the investment vehicle of choice for plan participants by examining various possible retirement wealth outcomes, in particular, the most adverse ones that could be generated by following such a strategy.

DATA AND METHODOLOGY

We examined the case of a hypothetical retirement plan participant with a starting salary of $25,000 and a contribution rate of 9%. The growth in salary is assumed to be 4% a year. The participant's employment life is assumed to be 41 years, during which regular contributions are made into the retirement plan account. For the sake of simplicity, we assumed that the contributions are credited annually to the accumulation fund at the end of every year, and the portfolio is also rebalanced at the same time to maintain the target asset allocation. Therefore, the first investment is made at the end of the first year of employment followed by 39 more annual contributions to the account.

A number of studies in recent years, including Hickman et al. [2001] and Shiller [2005b], compared terminal wealth outcomes of 100% stock portfolios with those of lifecycle portfolios and found little reason for investors to choose lifecycle strategies for investing retirement plan contributions. But these studies were not specifically designed to test whether the allocation toward stocks should be favored during the later stages of the investment horizon because of the growth in size of the investor's portfolio. The studies' competing strategies invest in different asset classes for differing lengths of time, and are therefore bound to result in different outcomes simply because of the return differentials between the asset classes. For example, it could be argued that a 100% stock portfolio may dominate a lifecycle portfolio purely because the former holds stocks over a longer duration. The role played by the growing size of the portfolio over time and its interplay with the asset allocation in influencing the final wealth outcome is not very clear from this result.

To discover whether, as the investor ages, the growth in the size of contributions and of the overall portfolio renders the conventional lifecycle asset allocation model counterproductive—as Shiller conjectures—we push the envelope a bit further. We considered hypothetical strategies that invest in less-volatile assets, such as bonds and cash, when a participant is younger, and then switch to invest in stocks as the participant grows older (i.e., strategies that reverse the direction of asset switching of conventional lifecycle models). These strategies, which we call *contrarian* strategies in this article, are well placed to exploit the high returns offered by the stock market as the participant's accumulation fund grows larger during the latter part of her career. Moreover, we designed the contrarian strategies to hold the invested asset classes for a length of time that is identical to the corresponding lifecycle strategies. This provision is necessary to ensure that we are not comparing apples to oranges as would be the case if we were to compare the outcomes of any lifecycle strategy with a fixed-weight strategy, such as holding 100% stocks throughout the investment horizon, or even with another lifecycle strategy that holds stocks (and other asset classes) for unequal lengths of time.[4]

Initially, we constructed four lifecycle strategies, all of which initially invest in a 100% stock portfolio, but start switching—after 20, 25, 30, and 35 years of the commencement of investing, respectively—from stocks to less-volatile assets (bonds and cash) at different points in time. We made a simplifying assumption that the switching of assets takes place annually in a linear fashion and in such a manner that in the final year before retirement all four lifecycle strategies are invested in bonds and cash only. The proportion of assets switched from stocks every year is equally allocated between bonds and cash.[5]

Next, we paired each lifecycle strategy with a contrarian strategy that is actually its mirror image in terms of asset allocation. In other words, the contrarian strategies replicate the asset allocation of lifecycle portfolios in the reverse order. All four contrarian strategies invest in a portfolio composed of only bonds and cash in the beginning and then switch linearly every year to stocks in proportions that mirror the asset switching for corresponding lifecycle strategies. The four pairs of lifecycle and contrarian strategies are the following:

Pair A. The lifecycle strategy (20, 20) invests only in stocks for the first 20 years and then linearly switches from stocks to bonds and cash over the remaining period. At the end of 40 years, all assets held are bonds and cash. The corresponding contrarian strategy (20, 20) invests only in bonds and cash in the initial year of investment. It linearly switches bonds and cash to stocks over the first 20 years, at the end of which the resultant portfolio is composed only of stocks. The 100% stock allocation remains unchanged for the next 20 years.

Pair B. The lifecycle strategy (25, 15) invests only in stocks for the first 25 years and then linearly switches stocks to bonds and cash over the remaining period. At the end of 40 years, all assets held are bonds and cash. The corresponding contrarian strategy (15, 25) invests only in bonds and cash in the initial year of investment. It then linearly switches bonds and cash to stocks over the first 15 years, at the end of which the resultant portfolio is composed only of stocks. The 100% stock allocation remains unchanged for the remaining 25 years.

Pair C. The lifecycle strategy (30, 10) invests only in stocks for the first 30 years and then linearly switches stocks to bonds and cash over the remaining period. At the end of 40 years, all assets held are bonds and cash. The corresponding contrarian strategy (10, 30) invests only in bonds and cash in the initial year of investment. It linearly switches bonds and cash to stocks over the first 10 years, at the end of which the resultant portfolio is composed only of stocks. The 100% stock allocation remains unchanged for the remaining 30 years.

Pair D. The lifecycle strategy (35, 5) invests only in stocks for the first 35 years and then linearly switches stocks to bonds and cash over the remaining period. At the end of 40 years, all assets held are bonds and cash. The corresponding contrarian strategy (5, 35) invests only in bonds and cash in the initial year of investment. It linearly switches bonds and cash to stocks over the first 5 years, at the end of which the resultant portfolio is composed only of stocks. The 100% stock allocation remains unchanged for the remaining 35 years.

The outlined test formulation allows us to directly compare wealth outcomes of a lifecycle strategy to those of a contrarian strategy that invests in stocks (and conservative assets) for the same duration, but at different points on the investment horizon. The allocation of any lifecycle strategy is identical to that of the paired contrarian strategy in terms of length of time invested in stocks (and conservative assets). The strategies only differ in terms of *when* they invest in stocks (and conservative assets)—that is, early or late in the investment horizon. For example, in the case of Pair A, both the lifecycle (20, 20) and contrarian (20, 20) strategies invest in a 100% stock portfolio for 20 years, and allocate assets in identical proportions between stocks and bonds/cash for the remaining 20 years. However, the former holds a 100% stock portfolio during the first 20 years of the horizon in contrast to the latter, which holds a 100% stock portfolio during the last 20 years of the horizon. The respective allocations are graphically demonstrated in Exhibit 1.

To generate investment returns under every strategy, we followed a random draw with replacement from the empirical distribution of asset class returns. The historical annual return data for the asset classes are randomly resampled with replacement to generate asset class return vectors for each year of the 40-year investment horizon of the DC plan participant. Thus we retained the cross-correlation between the asset class returns as given by the historical data series, while assuming that returns for individual asset classes are independently distributed over time. The asset class return vectors were then combined with the weights accorded the asset classes in the portfolio (governed by the asset allocation strategy) to generate portfolio returns for each year in the 40-year horizon. The simulated investment returns were applied to the retirement account balance at the end of every year to arrive at the terminal wealth in the account. For each lifecycle and contrarian strategy the simulation was iterated 10,000 times. Thus, each of the eight strategies has 10,000 investment return paths resulting in 10,000 wealth outcomes at the end of the 40-year horizon.

To resample returns, we used an updated version of the dataset of nominal returns for U.S. stocks, long T-bonds, and T-bills originally compiled by Dimson, Marsh, and Staunton [2002], and commercially available through Ibbotson Associates. The annual return data series covers the 105-year period from 1900 to 2004. Because the dataset spans several decades, we were able to capture the wide-ranging effects of favorable and unfavorable return events on the individual asset classes included in our test. The returns include reinvested income and capital gains.

RESULTS AND DISCUSSION

Comparing various parameters of the terminal wealth distribution for the lifecycle strategies and their contrarian counterparts provides us a fair view of their relative appeal to the retirement investor. In particular, we looked at the mean, median, and quartiles of the terminal wealth distribution of the different asset allocation strategies. Exhibit 2 provides these statistics. As even a cursory glance reveals, significant differences are noticeable in these numbers.

In each of the four pairs, the contrarian strategies result in much higher expected value (mean) than the lifecycle strategies. The difference is most striking for Pairs A and B as the mean wealth at retirement for the contrarian strategies exceeds that of the corresponding lifecycle strategies by more than $500,000. While the differences between expected values of the other two lifecycle and contrarian pairs (C and D) are less eye-popping, they are still very large.

It is important to note, however, that the mean is not the most likely outcome or even the average likely outcome for any of the strategies. This is apparent from the skewness of the terminal wealth distributions. The means of the distributions are much higher than the medians, which indicates the probability of achieving the mean outcome is much less than 50%. In other words, the participants would have to have better-than-average luck to achieve the mean outcome at retirement. The average outcome in this case is, therefore, much more accurately represented by the median of all outcomes.

But even an evaluation of the median estimates does not change the story. In all pairs, the contrarian portfolios beat the lifecycle portfolios hands down. For example, the contrarian (20, 20) strategy in Pair A results in a median

EXHIBIT 1
Asset Allocation at Different Points of Investment Horizon

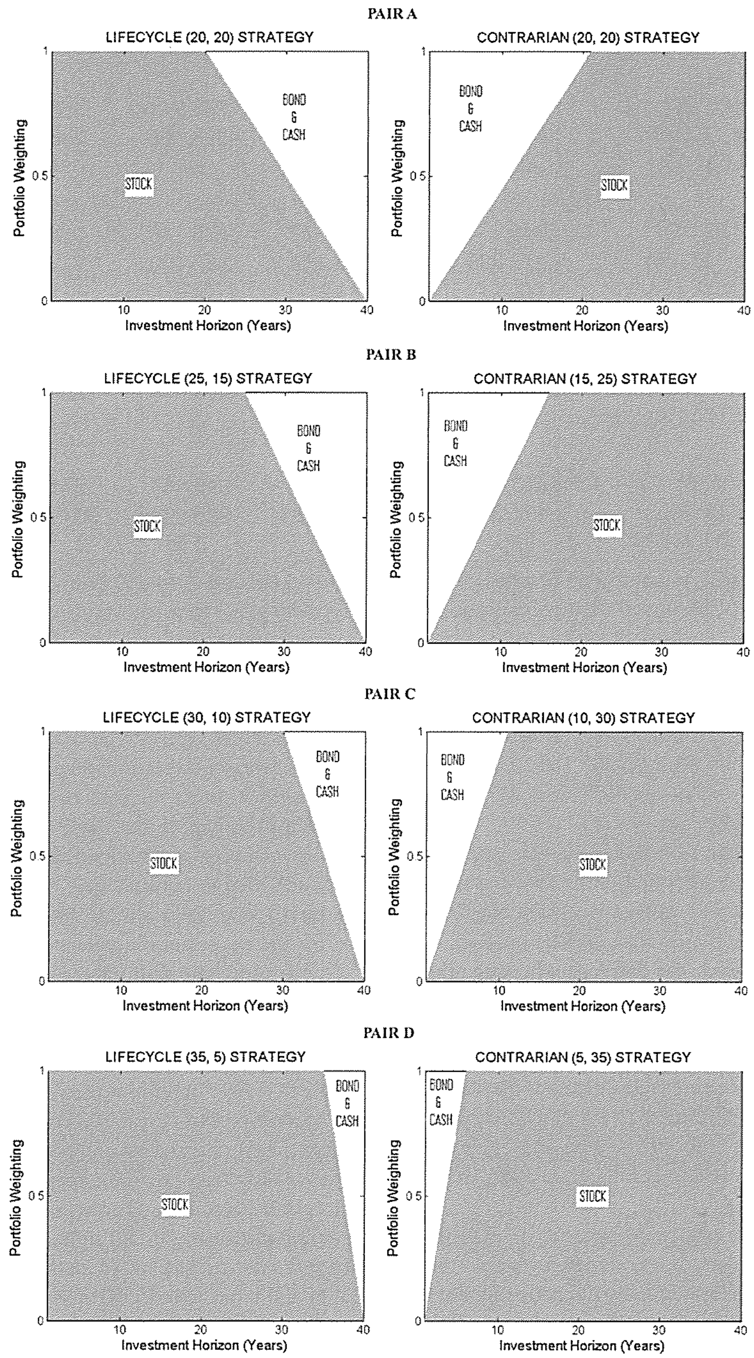


EXHIBIT 2
Terminal Value of Retirement Portfolio in Nominal Dollars

Strategy	Mean	Median	25th Percentile	75th Percentile
Pair A				
Lifecycle (20, 20)	1,420,332	1,160,225	793,371	1,724,852
Contrarian (20, 20)	1,959,490	1,425,387	838,796	2,435,856
CONT – LCYL (%)	38.0	22.9	5.7	41.2
Pair B				
Lifecycle (25, 15)	1,645,154	1,275,577	825,149	2,004,439
Contrarian (15, 25)	2,173,389	1,546,339	889,496	2,702,427
CONT – LCYL (%)	32.1	21.2	7.8	34.8
Pair C				
Lifecycle (30, 10)	1,909,918	1,411,168	876,711	2,355,363
Contrarian (10, 30)	2,335,373	1,587,699	909,020	2,864,003
CONT – LCYL (%)	22.3	12.5	3.7	21.6
Pair D				
Lifecycle (35, 5)	2,253,731	1,578,405	918,483	2,764,413
Contrarian (5, 35)	2,491,247	1,699,990	964,222	3,032,984
CONT– LCYL (%)	10.5	7.7	5.0	9.7

CONT– LYCL = Contrarian Strategy Terminal Value – Lifecycle Strategy Terminal Value
(Expressed as a percentage of the lifecycle strategy terminal value.)

final wealth of $1,425,387. The median final wealth of the corresponding lifecycle (20, 20) strategy is $1,160,225, thus falling short by a whopping $265,162. The same margins for Pairs B, C, and D, are $270,763, $176,531, and $121,584, respectively.

We also compared the 75th and 25th percentile estimates, which represent the midpoint of the above-average and below-average outcomes, respectively. For the 75th percentile estimates, which are practically the medians of the above-average outcomes, the differences between the lifecycle and the corresponding contrarian portfolios grow even wider than those for median estimates. For Pair A, the 75th percentile outcome for the contrarian portfolio is about 41% larger than the lifecycle portfolio, translating into a wealth difference of more than $700,000. Even for Pair D, for which the results of the two strategies are closest, the contrarian portfolio is still better off by more than $250,000.

The 25th percentile estimates represent the medians of the below-average outcomes. Thus, it would be expected that the lifecycle strategies would perform better in the 25th percentile estimates, given that these strategies are specifically designed to protect the retirement portfolio against adverse market movements in the final years of the investment horizon. They certainly do better in terms of closing the gap, but are still not able to outperform contrarian strategies for any of the pairs. Even in Pair C, for which the two estimates are closest, the result for the contrarian strategy is almost 4% ($32,000) higher than that for the corresponding lifecycle strategy.

Although the dominance of contrarian strategies over their lifecycle counterparts is clearly visible for all pairs, the difference between the outcomes of the two strategies gets monotonically smaller moving from Pair A to Pair D. This outcome is expected as each subsequent pair of strategies has greater overlap, in terms of holding the same asset class at the same point on the horizon (i.e., identical allocation), than the previous pair. For example, at no point in time do the two strategies—lifecycle (20, 20) and contrarian (20, 20) strategies—in Pair A have an identical asset allocation. In stark contrast, the lifecycle (35, 5) and contrarian (5, 35) strategies in Pair D have an identical allocation for 30 years (between the 6th and 36th years), during which both are invested 100% in stocks. Thus, the result is that the final wealth outcomes are closer to one another than those produced by other pairs in which the lifecycle and contrarian strategies have shorter overlapping periods of identical allocation.

These results indicate that if the plan participant's objective is to maximize wealth at the end of the investment horizon, lifecycle strategies vastly underperform relative to contrarian strategies. Shiller's emphasis on exposing the portfolio in later years to the higher returns of the stock market seems to be a possible candidate in explaining the superior 40-year performance of the contrarian strategies. But to gain a proper understanding of the interaction between portfolio size and asset allocation, it is necessary to track the accumulation paths of the lifecycle strategies and their corresponding contrarian strategies in the early, middle, and final years. In other words, in order to obtain more compelling evidence of the size effect, we need to plot the simulated portfolios over the entire 40-year period.

Exhibit 3 depicts the accumulation paths over 40 years for each pair of lifecycle and contrarian strategies. Because showing all the 10,000 simulated accumulation paths for every strategy would make the plots visually unappealing and difficult to study, we display every 100th simulation result in these graphs. Thus, for every strategy, we effectively plot 100 simulated accumulation paths for visual comparison with those of its counterpart.[6]

For every lifecycle and contrarian strategy, the slopes of the accumulation curves generally steepen as they move along the horizon.[7] This seems to indicate that the potential for rapid growth in the retirement account balance comes only in the later years. What is striking in this respect is that every lifecycle strategy and its paired contrarian strategy display quite similar accumulation outcomes in the initial years, despite the contrast in their asset allocation structures. In fact, through the first half of the horizon (20 years), little distinction can be made between the accumulation patterns of the lifecycle strategies and the contrarian strategies, although lifecycle strategies seem to do slightly better. This may be due to the fact that lifecycle strategies share shorter overlapping periods of identical asset allocation with their contrarian competitors; for example, the lifecycle strategies in Pairs A and B. It is only when the accumulation plots move well beyond the half-way mark on the horizon that they start to look strikingly different. This seems to suggest that the accumulation balance in the retirement account during the initial years may not be very sensitive to the asset allocation strategy chosen by the participant.

This finding confirms the importance of portfolio size growth along the investment horizon from the perspective of asset allocation. In the initial years, the size of the contributions is relatively smaller resulting in a smaller portfolio size. The return differentials between different asset allocation strategies during this period do not create large differences in the dollar value of the retirement portfolio. As the plan progresses along the investment horizon and the portfolio size grows larger, asset allocation assumes a more dominant role as small differences in returns result in large differences in accumulated wealth. The sensitivity of the absolute growth in accumulated wealth to the asset allocation becomes more and more pronounced in the final years before retirement when the size of the portfolio is larger than it was in the earlier years of the plan.

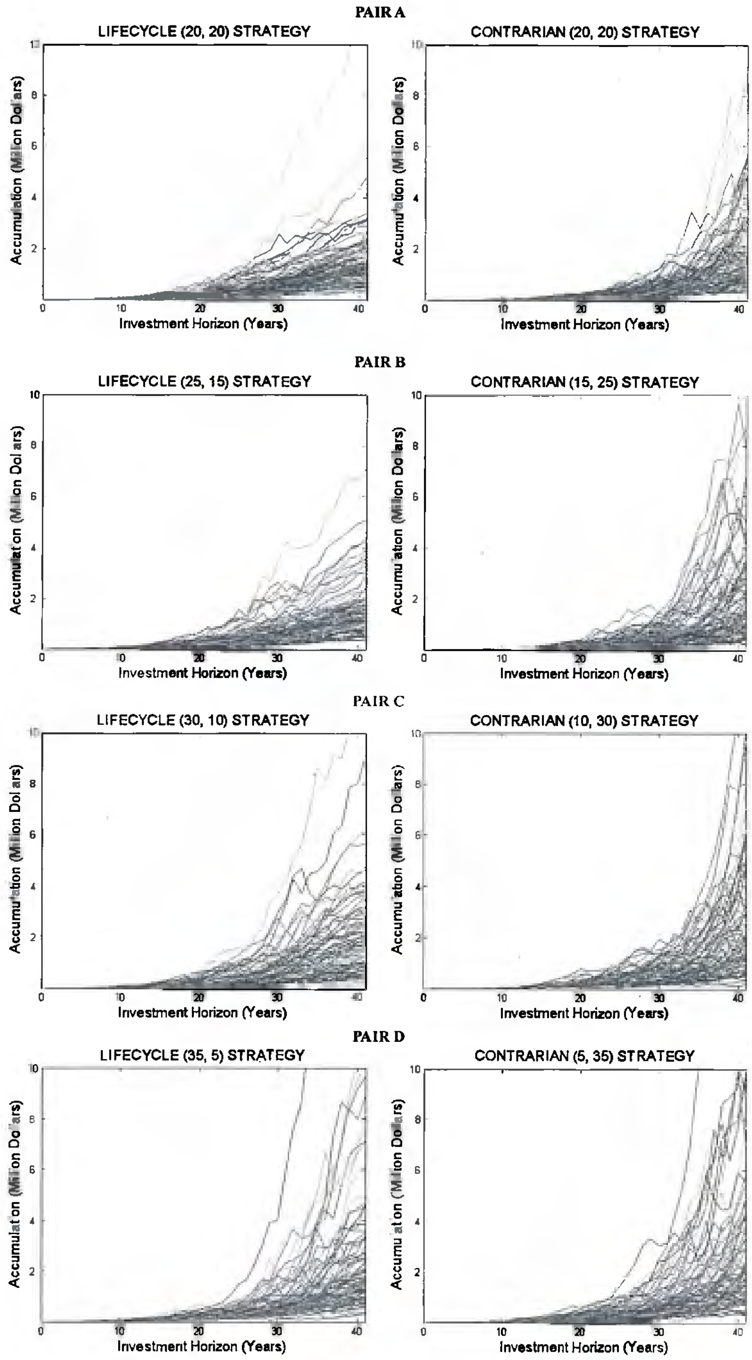
The slopes of the accumulation plots for lifecycle strategies and those for the corresponding contrarian strategies become conspicuously different during the later years of plan accumulation. In general, the accumulation values of the lifecycle portfolios gradually climb as the horizon progresses, while those of the contrarian portfolios display a steep ascent. This difference clearly demonstrates the effect of portfolio size on the terminal wealth outcome. By allowing the exposure of large portfolios to the stock market in later plan years, the contrarian strategies create opportunities for higher absolute growth in the accumulation balance.

A closer examination of the plots reveal that in many cases the contrarian portfolio values leapfrog over the lifecycle portfolios only at very late stages in the investment horizon, but still manage to result in huge differences in terminal portfolio value. For example, accumulation balances for the contrarian (20, 20) strategy in Pair A generally lag behind those of the lifecycle (20, 20) strategy for the best part of 40 years. In most cases, however, not only do they manage to catch up to the lifecycle portfolios in the final years before retirement, but actually leave them way behind by the time the investors reach the finish line.[8]

Yet, the fact that contrarian strategies are exposed to the possibility of serious market downturns close to the investor's retirement cannot be ignored. It is quite possible that the higher volatility of stock returns can result in large losses for contrarian strategies in later plan years and, therefore, very poor terminal accumulations. This is

Exhibit 3

Simulated Accumulation Paths over Investment Horizon



certainly evident from the sharp ups and downs in the accumulation plots for the contrarian strategies later in the horizon. Lifecycle accumulation plots, in contrast, generally seem to enjoy a relatively smooth ride during this period. But does this suggest lower risk for lifecycle strategies?

A possible approach for comparing the riskiness of the competing strategies would be to analyze the lower tail of the distribution, or the adverse wealth outcomes. If lifecycle strategies are less risky, they may generate better outcomes at the lower tail of the terminal wealth distribution compared to contrarian strategies. Exhibit 2 showed that the first quartile outcomes of contrarian strategies dominate those of lifecycle strategies in every case. Now, we compare various percentiles of distribution within the first quartile range that may be considered the zone of most adverse outcomes for the plan participant. Exhibit 4 tabulates the estimates for 1st, 5th, 10th, 15th, and 20th percentiles of the terminal wealth distributions under all strategies.

The estimates indicate that lifecycle strategies do produce better outcomes than their contrarian counterparts when only the outcomes in the lowest decile (10th percentile or below) of the distribution are considered. This outcome is not without exception, however. The 10th percentile outcome for the lifecycle (35, 5) strategy in Pair D is lower than that of the corresponding contrarian strategy. The difference between the outcomes for every pair is highest for the 1st percentile outcomes, and reduces gradually in the higher percentiles of the distribution. Remarkably, the final wealth under the contrarian strategies in the worst-case scenarios falls short of that of the corresponding lifecycle strategies by a margin that is far less than alarming considering the size of the overall accumulation. For 1st (and 5th) percentile measures, these margins range from a little more than \$100,000 (and \$75,000) for Pair A to about \$37,000 (and \$8,000) for Pair D. The difference between the outcomes seems to become less significant around the 15th percentile level, with the contrarian strategies resulting in slightly higher estimates for Pairs B and D. In the 20th percentile outcomes, the dominance of the contrarian strategies is clearly visible for all four pairs.

These results show that lifecycle strategies do not always fare better than the contrarian strategies, even in terms of reducing the risk of adverse outcomes. Only

EXHIBIT 4

Terminal Portfolio Values for Adverse Outcomes in Nominal Dollars

	Percentiles of Distribution				
Asset Allocation Strategy	**1**	**5**	**10**	**15**	**20**
Pair A					
Lifecycle (20, 20)	370,049	483,800	577,066	654,132	728,573
Contrarian (20, 20)	258,637	407,053	532,291	639,031	738,534
LCYL – CONT (%)	43.08	18.85	8.41	2.36	−1.35
Pair B					
Lifecycle (25, 15)	343,326	466,203	571,193	662,194	744,045
Contrarian (15, 25)	259,630	424,103	557,240	673,115	778,744
LCYL – CONT (%)	32.24	9.93	2.50	−1.62	−4.46
Pair C					
Lifecycle (30, 10)	318,211	470,271	585,107	685,409	781,134
Contrarian (10, 30)	249,829	434,660	567,613	682,174	803,828
LCYL – CONT (%)	27.37	8.19	3.08	0.47	−2.82
Pair D					
Lifecycle (35, 5)	301,184	455,267	589,409	700,323	817,011
Contrarian (5, 35)	264,326	446,592	600,863	719,279	843,420
LCYL – CONT (%)	13.94	1.94	−1.91	−2.64	−3.13

LYCL – CONT = Lifecycle Strategy Terminal Value – Contrarian Strategy Terminal Value
(Expressed as a percentage of the contrarian strategy terminal value.)

when we compare the 10th percentile (and below) outcomes—whose likelihood of occurrence is 1 in 10—lifecycle strategies fare slightly better. As a practical matter, it is very unlikely that investors would select a lifecycle asset allocation model with the sole objective of minimizing the severity of these extremely adverse outcomes—should they occur—because the cost of such action is substantial in terms of foregone wealth. For example, should the 10th percentile outcome be confronted at retirement, the plan participant would be better off by only roughly 8% by following the lifecycle (20, 20) strategy rather than the contrarian (20, 20) strategy. But should the 90th percentile outcome be confronted at retirement—which, of course, is as likely to happen as the 10th percentile outcome—the plan participant would be better off by 55% by following the contrarian (20, 20) strategy instead of the lifecycle (20, 20) strategy.[9] Obviously, the choice of one strategy over the other could be the deciding factor in whether the plan participant's retirement years are spent watching travel shows on television or actually holidaying in exotic destinations around the world.

The opportunity for risk reduction varies considerably among various lifecycle strategies. The ability to reduce risk appears to be greater for lifecycle strategies that start changing their asset allocation earlier in the investment horizon than those that do so later. For example, the 5th percentile outcome for the lifecycle (20, 20) strategy is almost 19% higher than that of the contrarian (20, 20) strategy. The same estimate for the lifecycle (25, 15), (30, 10), and (35, 5) strategies—which switch to conservative assets relatively later in the plan's life—vis-à-vis corresponding contrarian strategies shows 10%, 8%, and 2% better outcomes, respectively, which indicates a declining risk reduction advantage for lifecycle strategies that delay switching to conservative assets. Ironically, reducing the risk of extreme outcomes by switching early to conservative assets involves a very heavy penalty in terms of foregone accumulation of wealth. This becomes apparent from the variation in terminal wealth outcomes for the four lifecycle strategies in question.

CONCLUSION

The apparently naïve contrarian strategies which, defying conventional wisdom, switch to risky stocks from conservative assets produce far superior wealth outcomes relative to conventional lifecycle strategies in all but the most extreme cases. This demonstrates that the size of the portfolio at different stages of the lifecycle exerts substantial influence on investment outcomes and, therefore, should be carefully considered when making asset allocation decisions. The evidence presented in this article lends support to the view espoused by Shiller [2005a] that the growing size of the plan participant's contributions in later years calls for aggressive asset allocation—quite the opposite of the strategy currently followed by lifecycle asset allocation funds.

It is important to emphasize that we are clearly not suggesting that a retirement plan participant should follow any of the contrarian asset allocation strategies to allocate plan assets. We have formulated and used them in this article only to conduct a fair test of the hypothesis that by investing conservatively in the middle and later years of the participant's investment horizon, lifecycle funds work against the participant's investment objectives. Our results show that, in most cases, the growth in portfolio size experienced in the later years of employment seems to justify holding a portfolio that is at least as aggressive as that held in the early years. For some participants, that may well mean holding 100% stocks throughout the horizon.

By their own admission, financial advisors who recommend lifecycle asset allocation strategies focus on two objectives: maximizing growth in the initial years of investing and reducing volatility of returns in the later years. Our findings suggest that the bulk of the growth in value of accumulated wealth actually takes place in the later years. The first objective, therefore, has little relevance to the overarching investment goal of augmenting the terminal value of plan assets. We do find some support for pursuing the second objective of reducing volatility in later years to lessen the impact of severe market downturns, but this comes at the high cost of forfeiting significant upside potential. In other words, the effect of portfolio size on wealth outcomes over long horizons is so large that it outweighs, in most cases, the volatility reduction benefit of lifecycle strategies. Therefore, switching to less volatile assets a few years before retirement can only be rationalized if the plan participant has already accumulated wealth that equals or exceeds the retirement target.

If lifecycle strategies aim to preserve accumulated wealth, then sufficient accumulation has to be ensured in the retirement account before the recommendation is made to switch to more conservative investments. Unfortunately, this is not the case with the lifecycle funds currently used in DC plans. Currently available lifecycle funds switch from riskier to more conservative assets according to a predetermined mechanistic allocation rule, regardless of the actual accumulation in the account. Based on our findings, we have concluded that retirement investors would be better off by refraining from blindly adopting age-based investment strategies (lifecycle funds) that are keen on preservation even when there is not much to preserve.

ENDNOTES

This research was supported under the Australian Research Council's Discovery Grant (project number DP0452336). The authors are particularly grateful to Prof. Martin Gruber for valuable feedback on the paper during their visit to the Stern School of Business, New York University. Comments from participants at the 12th Melbourne Money and Finance Conference and the 15th PBFEAM Conference are also acknowledged. The authors thank an anonymous reviewer for helpful comments on the article.

[1]Not all lifecycle funds change their asset allocation over time. Static allocation funds, which have the same exposure to various asset classes throughout the investment horizon, are also sometimes categorized as lifecycle or lifestyle funds. In contrast, the lifecycle funds we discuss in this article change their allocation over time and, therefore, are often referred to as age-based or target retirement funds. It is this type of age based lifecycle fund that has witnessed the highest growth in the last few years (Mottola and Utkus [2005]).

[2]For example, McEnally [1985] and Butler and Domian [1991] examined the effect, but reached different conclusions. This is, however, a result of the different measures of risk employed in these studies. The former viewed variability of terminal wealth as the risk measure and the latter used probability of stocks underperforming bonds and T-bills over long horizons as the risk measure.

[3]An exception to this is Hickman et al. [2001] who modeled the terminal value of a retired investor's portfolio to which contributions were made every month. The study assumed, however, that contributions remained equal throughout the horizon.

[4]An exception would be the case in which the average allocation of the lifecycle strategy to any asset class over the investment horizon exactly matches that of the fixed-weight strategy it is compared with.

[5]Information about precise asset allocation of existing lifecycle funds at every point on the horizon is rarely made available in the provider's prospectus. Our formulation follows the general direction of the switch and does not try to consciously replicate the allocation of any of the existing funds.

[6]We have chosen to use a linear scale over a logarithmic scale in plotting the accumulation wealth along the y-axis. This is motivated by our interest in absolute growth of the accumulation balance in actual dollars rather than percentage growth. Graphs using a logarithmic scale for the y-axis can be made available by the authors upon request. It should also be noted that a few extremely large accumulations for both lifecycle and contrarian strategies in the Pairs C and D do not completely fit in the graphs.

[7]This phenomenon is not unexpected because of the compounding of investment returns over multiple periods. Moreover, contributions are made to the retirement account every period and the size of the contributions grows larger every period under our assumption of constant growth in salary.

[8]Obviously, exceptions are visible in the diagrams of instances when an individual accumulation plot under the lifecycle strategy is able to beat those under the contrarian strategies.

[9]The 90th percentile terminal wealth estimates, although not provided in this article, are available from the authors upon request.

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Dynamic Lifecycle Strategies for Target Date Retirement Funds

ANUP K. BASU, ALISTAIR BYRNE, AND MICHAEL E. DREW

ANUP K. BASU
is a lecturer in the School of Economics and Finance at Queensland University of Technology in Brisbane, Australia.
a.basu@qut.edu.au

ALISTAIR BYRNE
is a principal consultant at Investit Ltd in London, U.K.
alistair.byrne@investit.com

MICHAEL E. DREW
is a professor of finance in the Department of Accounting, Finance and Economics at Griffith University in Brisbane, Australia.
michael.drew@griffith.edu.au

Target date retirement funds have gained favor with retirement plan investors in recent years. Typically, these funds initially have a high allocation to stocks but move towards less volatile assets, such as bonds and cash, as the target retirement date approaches. Thus, we are told, they offer the best of both worlds—robust portfolio growth in the early years and preservation of the accumulated wealth as the investor comes closer to retirement. And the best part of all is that once enrolled there is no need for investors to keep constant watch over their investment strategy. Ameriks and Zeldes [2004] and others have highlighted the problem of inertia among retirement plan participants, which is often manifested in the reluctance to change allocation of their plan assets through time. Because target retirement funds automatically switch assets following a preset glide path laid down by the plan provider, they are thought to be an effective antidote to this apparent flaw in investor behavior.

But does the strategy of switching out of equities with time, popularly known as lifecycle investing, benefit investors? Empirical research has generally found that a switch to low-risk assets prior to retirement can reduce the risk of confronting the most extreme negative outcomes. Lifecycle investment strategies are also said to reduce the volatility of wealth outcomes making them desirable to investors who seek a reliable estimate of final pension a few years before retirement; see, for example, Blake, Cairns, and Dowd [2001]. Most researchers note, however, that these benefits come at a substantial cost to the investor, that is, the cost of giving up significant upside potential of wealth accumulation offered by more aggressive strategies (Booth and Yakoubov [2000] and Byrne et al. [2007]). Cairns, Blake, and Dowd [2006] found conventional lifecycle strategies inferior to static asset allocation strategies as well as to a stochastic lifecycle strategy, which considers different risk attitudes of investors and correlation between their salaries and asset returns. Bodie and Treussard [2007] argued that target date funds, as commonly implemented, are optimal for some investors but not for others, with suitability depending on the investor's risk aversion and human capital risk.

Our article questions the rationale for lifecycle switching based solely on age or target retirement date as is the prevalent practice among target date funds. We argue that a dynamic switching strategy, which takes into consideration achieved investment returns, will produce superior returns for most investors compared to conventional lifecycle switching. The most common argument cited by proponents of the latter is relatively straightforward—the probability that stocks will outperform (underperform) bonds and that cash increases (decreases) with the length of the investment horizon. If this is true, then long-horizon investors may prefer to have a higher allocation to stocks in their portfolio compared to investors with shorter investment horizons.[1] It is also argued that younger investors in retirement plans should heavily invest in stocks because they have enough time to recover from a stock market downturn, should that happen, and can work longer to make up for financial losses. But for older investors with only a few years to retirement, holding such an aggressive portfolio can spell disaster. A major slump in the stock market just before retirement can potentially wipe away years of investment gains with little time to salvage the situation. But would this imply that investors should automatically reduce the proportion of stocks in their retirement portfolio as the years go by? The following example would explain why the answer is not always yes.

Suppose an investor has a horizon of 40 years. Following a conventional lifecycle strategy, the investor decides to put most of her money in stocks for the initial 20 years and then gradually switch to bonds and cash over the last 20 years. Once this allocation decision is made, she puts the strategy on an autopilot (like most target date funds) and goes to sleep. However, the stock market returns following the investment decision do not augur well for the investor. Due to a prolonged bear market, several years of negative returns erode the value of her portfolio. After 20 years, the balance in her account is next to nothing, but it is gradually switched to bonds and cash as dictated by the lifecycle strategy. Subsequent returns in the account are stable, but low. When our "Rip Van Winkle" investor wakes up after 40 years, she finds herself in a financial situation quite different from what was anticipated when setting the investment strategy. She may even find herself poorer in real terms than she was 40 years ago.

Undoubtedly the preceding example is extreme and describes only one of several possibilities that an investor can expect to encounter over a long horizon. Yet it reveals the Achilles' heel of the lifecycle funds currently in the market. These funds follow a predetermined "Rip Van Winkle" asset allocation strategy in which not only the switching of assets is always unidirectional—from stocks to fixed income—but is also done in proportions that are pre-specified at the inception of the fund. In our example, had the stock market offered very high returns over the last 20 years, the investor would have gained very little because her investments were automatically being switched from stocks to bonds and cash in keeping with the allocation strategy she had set on autopilot. The pre-programmed conventional lifecycle strategy is blind to the fact that the investor has accumulated too little wealth in the initial years of the strategy to begin switching to conservative assets. The asset switching in such a case virtually ensures that the investor misses the only realistic chance she has to reverse her bad fortune.

The problem for retirement plan members enrolled in target date funds goes even deeper than the problems faced by our hapless investor. Typically, plan members make regular contributions to the retirement account as opposed to a single investment made at the beginning of the 40-year period, as was the case in our example. Because contributions are normally a fixed percentage of a member's salary, they are expected to grow larger over time with the member's growth in earning power. Therefore, as Shiller [2005] pointed out, the lifecycle strategy is heavily in the stock market in the early years when the contribution size is relatively small and switches out of it when earnings and contributions grow larger in later years. This can be counterproductive because by moving away from stocks to low-return assets just when the size of their contributions (and accumulated fund) are growing larger, the investor may be foregoing the opportunity to earn higher returns on a larger sum of money invested. Basu and Drew [2009] confirmed this view by demonstrating that the growth in portfolio size over time is important from an asset allocation perspective, and by ignoring this phenomenon, lifecycle strategies tend to typically dampen the growth potential of the retirement investor's portfolio.

One cannot help wondering why conventional lifecycle funds need to have their benchmark asset allocation policy cast in stone. Basu and Drew [2009] suggested that lifecycle switching to less volatile assets as the investor ages can be beneficial only if it is conditional on the balance in the retirement account meeting the plan member's accumulation target. In other words, they argued that a switching strategy that uses performance feedback in making decisions about whether and how much to switch would be superior to the age-based—but performance-blind—lifecycle switching. This contention has not yet been put to an empirical test.

In this article, we put forward a dynamic lifecycle switching strategy that is conditional on the attainment of the plan member's wealth accumulation objective at every stage of switching. We compare and contrast the retirement wealth outcomes of this strategy with the conventional lifecycle strategy, which is unconditionally tied to the age-based glide path, and other static asset allocation strategies. Our study, therefore, provides useful evidence to answer the question of whether a dynamic lifecycle strategy is indeed superior to the conventional lifecycle strategy, as conjectured by Basu and Drew [2009], as well as to assess its standing vis-à-vis other comparable strategies.

The dynamic lifecycle strategy is responsive to past performance of the portfolio relative to the investor's target return in determining the mix of assets in future periods. While it initially invests heavily in equities just as any other lifecycle strategy, the switching to fixed income is not automatic. It only takes place if the investor has accumulated wealth in excess of the target accumulation at the point of switch. Also, after switching to conservative assets, if the accumulation falls below the target in any period, the direction of switch is reversed by moving away from fixed income and towards stocks. Hence, the article proposes and tests a lifecycle strategy where the switching is not unidirectional.

Blake, Cairns, and Dowd [2001] have considered including performance feedback in the asset-switching design. The dynamic lifecycle strategy proposed in this article, however, differs in three important ways from the threshold strategy put forward by Blake, Cairns, and Dowd. First, the threshold strategy sets two distinct thresholds (upper and lower) to determine the direction and extent of asset switching. In this article, the asset switching is governed by a single benchmark—the accumulation target set by the investor. We think that the target-rate-of-return approach is simpler and more intuitive for the typical retirement investor. Moreover, while the different sets of values used as thresholds in the former appear to be arbitrary, the accumulation target in our article is cognizant of the past returns from the U.S. stock market. (We explain this in the following section.) Second, the asset switching in the dynamic lifecycle strategy proposed in our article takes place in the final 10 or 20 years before retirement, which is similar to most target date, or lifecycle, funds offered by plan providers. In contrast, the threshold strategy proposed by Blake, Cairns, and Dowd commences immediately after the member joins the retirement plan.

We arrive at a very different result from Blake, Cairns, and Dowd [2001]. The threshold strategy they employ is dominated by the conventional lifecycle strategy by close to first-order stochastic dominance. In sharp contrast, the dynamic lifecycle strategy we employ in this article has Almost Stochastic Dominance over the conventional lifecycle strategy as well as the balanced strategy and, therefore, appears to be a superior alternative.

COMPARING CONVENTIONAL AND DYNAMIC LIFECYCLE STRATEGIES

In comparing conventional and dynamic lifecycle strategies, we consider the case of a hypothetical individual who joins the plan with a starting salary of $25,000. The earnings grow linearly at the rate of 4% a year over the next 41 years, approximating the duration of the individual's working life. Throughout this period, regular annual contributions amounting to 9% of earnings go into the retirement plan account.[2] We assume that the contributions are credited annually to the member's account at the end of each year. This means that the first contribution by the member is made at the end of the first year followed by 39 more contributions in as many years. No contribution is made in the final year of employment.

Our hypothetical plan member can choose between a conventional lifecycle strategy and a dynamic lifecycle strategy. We consider two variations of the conventional lifecycle strategy, namely, $LC_{20,20}$ and $LC_{30,10}$, both of which invest in a 100% stocks portfolio for 20 years and 30 years, respectively, following the first contribution. Thereafter, both strategies switch linearly from stocks to bonds and cash over the remaining 20 (or 10) years in such a manner that at the point of retirement all assets are held in bonds and cash. This type of allocation is typical of lifecycle, or target date, strategies used in practice. Similarly, the dynamic lifecycle strategy has two variations, namely, $DLC_{20,20}$ and $DLC_{30,10}$. They invest in the same 100% stocks portfolio as the two conventional lifecycle strategies during the first 20 (and 30) years. Thereafter, each year the strategies review how the portfolio has performed relative to the investor's accumulation objective. If the value of the portfolio at any point is found to equal or exceed the investor's target, the portfolio partially switches to conservative assets. Otherwise, it remains invested 100% in stocks.

If the switch to conservative assets has begun and the cumulative performance drops below target, the fund is switched back into growth assets. From our formulation of the strategies, it is clear that while $DLC_{20,20}$ and $DLC_{30,10}$ use performance feedback control in switching assets, $LC_{20,20}$ and $LC_{30,10}$ do not.

Although individuals may have different accumulation objectives on retirement, we need to make an assumption about the target set by the hypothetical individual employing the dynamic lifecycle strategies discussed in this article. Dimson, Marsh, and Staunton [2002] have compiled returns for U.S. stocks, bonds, and bills from 1900. We use an updated version of their dataset and find that the geometric mean return offered by U.S. stocks between 1900 and 2004 is 9.69%. We assume that the individual sets a target return close to this rate, say, 10%, on the retirement plan investments. In other words, the retirement portfolio under the dynamic lifecycle strategy aims to closely match the compounded accumulation of a fund in which contributions are annually reinvested at 10% nominal rate of return.

For $DLC_{20,20}$, which invests in a 100% stocks portfolio for 20 years, we assume that the individual sets a target of a 10% compounded annual rate of return on investment for the initial 20-year period. At the end of 20 years, if the actual accumulation in the retirement account exceeds the accumulation target, the assets are switched to a more conservative portfolio composed of 80% stocks and 20% fixed income (equally split between bonds and cash). But if the actual accumulation in the account is found to fall below the target, the portfolio remains invested in 100% stocks. This performance review process is carried out annually for the next 10 years and the asset allocation is adjusted depending on whether the holding period return is greater or less than the target, which remains set at a 10% annualized return on a cumulative basis. In the final 10 years, the same allocation principle is applied with one difference. If the value of the portfolio in any year during this period matches or exceeds the investor's target accumulation (i.e., 10% annualized cumulative return), at that point 60% of assets are invested in equities and 40% in fixed income (equally split between bonds and cash). The failure to achieve the target return for the holding period results in all assets being invested in the 100% stocks portfolio.

Similar principles are applied for $DLC_{30,10}$, which invests in 100% stocks for the 30 years following the first contribution. After 31 years, if the portfolio value in any year matches or exceeds the target accumulation, 20% of assets are switched to fixed income (equally split between bonds and cash). A failure to achieve the target performance results in the portfolio being invested in 100% equities. The performance of the portfolio relative to the target is monitored annually and the asset allocation is adjusted accordingly. In the final 5 years before retirement, if the portfolio performance at any point matches or exceeds the target accumulation at that point, 40% of assets are switched to fixed income (equally split between bonds and cash).

SIMULATING WEALTH OUTCOMES

To generate simulated investment returns under the two conventional lifecycle strategies (say, $LC_{20,20}$ and $LC_{30,10}$) and their corresponding dynamic lifecycle strategies ($DLC_{20,20}$ and $DLC_{30,10}$), we use an updated version of the dataset of annual nominal returns for U.S. stocks, bonds, and bills originally compiled by Dimson, Marsh, and Staunton [2002] and commercially available through Ibbotson Associates. The descriptive statistics are presented in Exhibit 1. The dataset spans a period of 105 years between 1900 and 2004, and thus captures both favorable and unfavorable returns on the individual asset classes over the entire 20th century. However, to examine holding period returns of assets over horizons as long as 40 years, 105 years worth of returns data may not be sufficient. There are only two independent, non-overlapping 40-year holding period observations within our dataset. Any conclusion based on a sample of two observations cannot be deemed reliable.

To get around the problem of insufficient data, we use bootstrap resampling. The empirical annual return

EXHIBIT 1
Descriptive Statistics of Nominal Returns Data

	Stocks	Bonds	Cash
Mean	11.6%	5.3%	4.1%
Median	14.0%	4.0%	4.0%
Maximum	58.0%	40.0%	15.0%
Minimum	−44.0%	−9.0%	0.0%
Standard Deviation	20.0%	8.2%	2.9%
Skewness	−0.32	1.53	0.72
Kurtosis	2.78	6.68	4.18
Observations	105	105	105

vectors for the three asset classes in the dataset are randomly resampled with replacement to generate asset class return vectors for each year of the 40-year investment horizon confronting the two hypothetical retirement plan investors. Since we randomly draw rows (representing years) from the matrix of asset class returns, we are able to retain the cross-correlation between the asset class returns as given by the historical data series while assuming that returns for individual asset classes are independently distributed over time.[3]

Because the resampling is done with replacement, a particular data point from the original dataset can appear multiple times in a given bootstrap sample. This is particularly important in examining the probability distribution of future outcomes. For example, 1931 is the worst year for the stock market in our 105-year dataset. In that year the return from stocks was −44%, while bonds and bills produced returns of 1% and −5%, respectively. Although this is only one observation in a century's worth of data, a bootstrap sample of 40 yearly returns can include the return observation for 1931 many times in any sequence. Similarly, return observations for other years, good or bad, can also be repeated a number of times within a bootstrap sample. Because this method allows for inclusion of such extreme possibilities—such as a −44% return occurring a number of times in a particular 40-year return path—a much wider range of future possibilities can be captured by obtaining a large number of bootstrap samples from the observed historical data.

The asset-class return vectors obtained by bootstrap resampling are combined with their respective weightings under each asset allocation strategy to generate portfolio returns for each year in the 40-year horizon. The simulation trial is iterated 10,000 times for the lifecycle strategy $LC_{20,20}$ and its corresponding dynamic strategy $DLC_{20,20}$, thereby generating 10,000 independent 40-year return paths that would govern the possible wealth outcomes for the individuals following them. A separate experiment (comprising another 10,000 trials) is conducted for the other pair of conventional and dynamic lifecycle strategies, $LC_{30,10}$ and $DLC_{30,10}$. For a comparative analysis, we include in both sets of experiments two other allocation strategies: 1) a 100% stocks strategy and 2) a balanced strategy that allocates in the ratio of 60:30:10 among stocks, bonds, and cash. We provide the results in the next section.

SIMULATION RESULTS

The resampling method described in the preceding section generates a range of terminal wealth outcomes under the conventional lifecycle strategies and their corresponding dynamic lifecycle strategies. The parameter estimates for the wealth distribution under the different strategies are reported in Exhibit 2. Panel A, which provides the results for the conventional lifecycle and dynamic lifecycle strategies that remain invested in 100% stocks for the first 20 years, shows a stark difference. The mean and the median outcomes for the dynamic lifecycle strategy $DLC_{20,20}$ exceed those for the conventional lifecycle strategy $LC_{20,20}$ by more than a half-million dollars. The first- and third-quartile estimates for the former are also greater than the latter by \$245,033 and \$704,324, respectively. Panel B of Exhibit 2 reports the results for the lifecycle strategies that always invest in the 100% stocks portfolio for the first 30 years. As in Panel A, the dynamic lifecycle strategy $DLC_{30,10}$ produces a much higher mean, median, and first- and third-quartile outcomes than the conventional lifecycle strategy $LC_{30,10}$. The gap between the outcomes in this case, however, is lower than it was between $DLC_{20,20}$ and $LC_{20,20}$. This is

EXHIBIT 2
Terminal Value of Retirement Portfolio in Nominal Dollars

Strategy	Mean	Median	25th Percentile	75th Percentile
Panel A				
$DLC_{20,20}$	1,978,387	1,733,256	1,037,838	2,432,030
$LC_{20,20}$	1,426,510	1,163,836	792,805	1,727,706
100% Stocks	2,523,681	1,715,014	981,005	3,040,650
Balanced	1,273,744	1,117,258	804,466	1,562,407
Panel B				
$DLC_{30,10}$	2,243,825	1,762,712	988,573	2,695,902
$LC_{30,10}$	1,919,124	1,408,545	876,404	2,340,550
100% Stocks	2,547,867	1,716,608	965,411	3,102,896
Balanced	1,276,875	1,118,547	799,502	1,573,030

Note: Results are based on 10,000 simulations.

expected because $DLC_{30,10}$ and $LC_{30,10}$ strategies invest in the same portfolio (100% stocks) for 10 more years.

In addition to the conventional and the dynamic lifecycle strategies that are of primary interest in this article, we also simulate for comparison the wealth outcomes of the 100% stocks strategy and the balanced strategy. The mean outcomes for the 100% stocks strategy are higher than both the conventional and dynamic strategy pairs. Given the existence of a large positive equity premium in our data, this is unsurprising. While the median and the first-quartile outcomes for the 100% stocks strategy are higher than those of $LC_{20,20}$ and $LC_{30,10}$, they fall short of both $DLC_{20,20}$ and $DLC_{30,10}$. This suggests that dynamic strategies are superior in protecting investors from the risk of adverse outcomes than both the aggressive 100% stocks strategy and the conventional lifecycle strategy, which adopts a pre-determined conservative allocation in later years.

The ineffectiveness of lifecycle switching in protecting investors from the risk of confronting adverse wealth outcomes on retirement is clear when we look at the balanced fund simulation results. The balanced fund, whose mean and median outcomes are inferior to the other three strategies, outperforms $LC_{20,20}$ in terms of the first-quartile estimate. This appears to put a question mark on the efficacy of the conventional lifecycle strategies. Dynamic lifecycle strategies, again, seem to produce better results in this respect. We take up this issue later in the article.

Despite the dynamic strategies ($DLC_{20,20}$ and $DLC_{30,10}$) outperforming their conventional lifecycle counterparts ($LC_{20,20}$ and $LC_{30,10}$) in terms of the mean, median, and the lower- and upper-quartile outcomes, can we conclude they are superior investment vehicles for the retirement plan members? This cannot be answered with certainty without comparing the entire range of outcomes under the two approaches. Stochastic dominance is a well-known approach used in this type of situation because it considers the entire distribution of outcomes.[4] It also places minimal restrictions on the investors' utility functions and makes no assumptions, such as normality, about the distributions. The stochastic dominance approach has been employed in a wide range of areas including investments, operations research, medicine, and agriculture.[5] We use this approach here to find out whether investors would prefer the terminal wealth distribution under one asset allocation strategy over that of the other.

Formally, given that utility of wealth is a non-decreasing function (i.e., $U'(W) \geq 0$), if F and G represent the cumulative distributions of terminal wealth outcomes under the dynamic lifecycle strategy and the conventional lifecycle strategy, respectively, the former dominates the latter under the stochastic dominance (SD) rule if, and only if,

$$F(W) \leq G(W) \quad \forall W$$

In plain words, this means that the dynamic lifecycle strategy would dominate the corresponding conventional lifecycle strategy by the SD criterion if the cumulative distribution of terminal wealth outcomes under it always remains below the cumulative wealth distribution of the conventional lifecycle strategy. This rule is also known as First Degree Stochastic Dominance (FSD).[6]

One serious limitation of the stochastic dominance approach in ranking alternatives is that it operates under very restrictive condition often violated in real-world situations.[7] In view of this difficulty, Leshno and Levy [2002] proposed an alternative in the form of Almost Stochastic Dominance (ASD), which captures all reasonable preferences, and therefore is acceptable as an ordering criterion by *most* decision makers.[8] ASD allows for violation of the condition that F has to always remain below G for the former to dominate the latter as long as the area between F and G that causes the violation (left of point X) is very small compared to the total area between the two distributions. If ε denotes the ratio between the area of the FSD violation and the total area between F and G, then the smaller ε is, the smaller is the area of violation relative to the full range of outcomes and more investors would prefer F over G. In other words, F is said to have "almost FSD dominance" over G.

Although the magnitude of ε presumably is different for different sets of investors, an experimental study conducted by Levy, Leshno, and Leibovitch [2006] among undergraduate and graduate students and mutual fund managers estimated the value of ε to be 5.9%, or 0.059. To apply the ASD rule extremely conservatively, we would consider $0 < \varepsilon < 0.01$ as acceptable for dominance by ASD, where there is no clear dominance by FSD. Setting such a low threshold of 0.01 for ε would eliminate any realistic chance of error on our part in applying the ASD criterion.

Exhibit 3 demonstrates the cumulative distributions of terminal wealth achieved under $LC_{20,20}$ and $DLC_{20,20}$ strategies. Again, for the purpose of comparison, we show cumulative wealth distributions for the 100% stocks and the balanced strategies. The horizontal axis of the graph represents the nominal dollar value of the portfolio at the point of retirement. As explained earlier, if the CDF for one strategy lies under (or to the right of) other CDFs, it is likely to result in a superior outcome relative to other strategies. Also, if the CDF for a strategy is generally steeper than the others, the strategy can be considered to result in less variable outcomes.

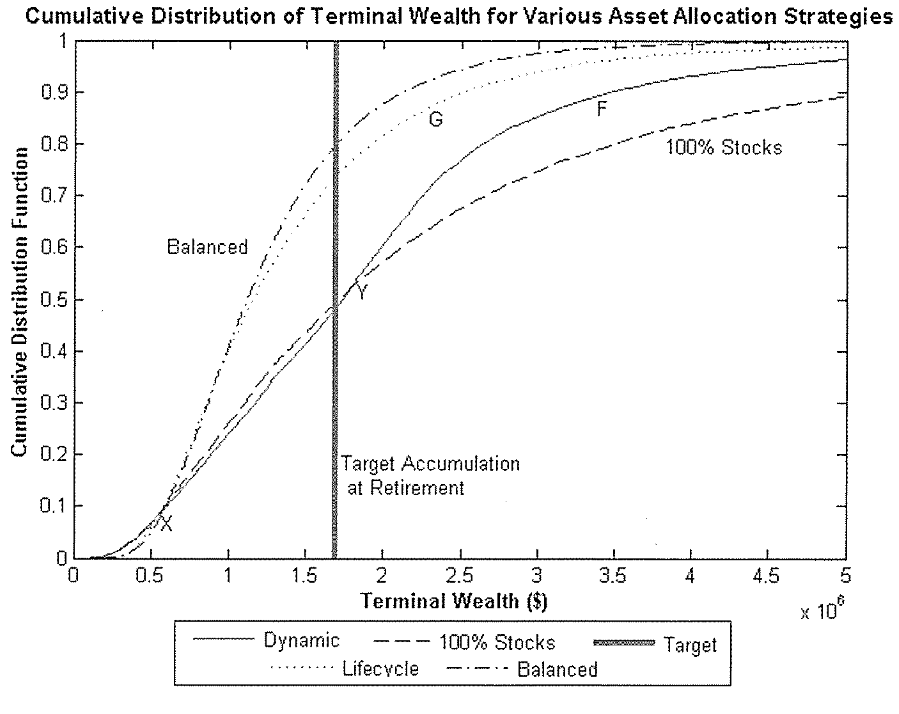
It is clear that except for a very small part to the left of the point *X*, the cumulative distribution plot of $DLC_{20,20}$ remains under that of $LC_{20,20}$. Therefore, the dynamic lifecycle strategy dominates the conventional lifecycle strategy to the right of point *X* but not to the left of it. Thus, there is violation of the strict SD criterion, the area of violation being denoted by the area between the distribution plots *F* and *G* to the left of *X*.

Except for a very small section to the left of point *X* representing wealth outcomes of about $500,000 or less after 41 years, we can infer from the cumulative distributions that the investor employing $DLC_{20,20}$ has a higher chance of achieving any particular accumulation outcome than the investor employing $LC_{20,20}$. For example, the former has about a 75% probability of accumulating more than one million dollars at retirement, whereas the latter has only a 60% chance of crossing that milestone. If investors set a target of achieving a compounded return of 9% minimum on their investments, which amounts to accumulated wealth of at least $1.69 million at retirement, our results indicate that the $DLC_{20,20}$ strategy would achieve this goal with almost 50% certainty. With the $LC_{20,20}$ strategy, the probability drops to only 25%. The gap between the cumulative distribution functions for the two strategies widens as we move up towards higher accumulation figures, although after a point (roughly around two million dollars) its starts diminishing gradually.

A comparison of the cumulative distributions of the lifecycle strategies $LC_{20,20}$ and $DLC_{20,20}$ with that of the 100% stocks strategy reveals two important results. First, we find that the distribution of the conventional

EXHIBIT 3

Cumulative Distribution Plots for the First Pair of Lifecycle and Dynamic Strategies ($LC_{20,20}$ and $DLC_{20,20}$)



lifecycle strategy, $LC_{20,20}$, always remains above that of the 100% stocks strategy except for the small section to the left of point *X* (representing only about the worst 5% of outcomes). This questions the effectiveness of conventional lifecycle strategies in protecting investors' wealth from the vagaries of stock market downturns. Had it been the case, we would have found *X* much to the right of its current location (i.e., $LC_{20,20}$ would have dominated the 100% stocks strategy for a much larger percentage of outcomes in the lower end of the distribution).

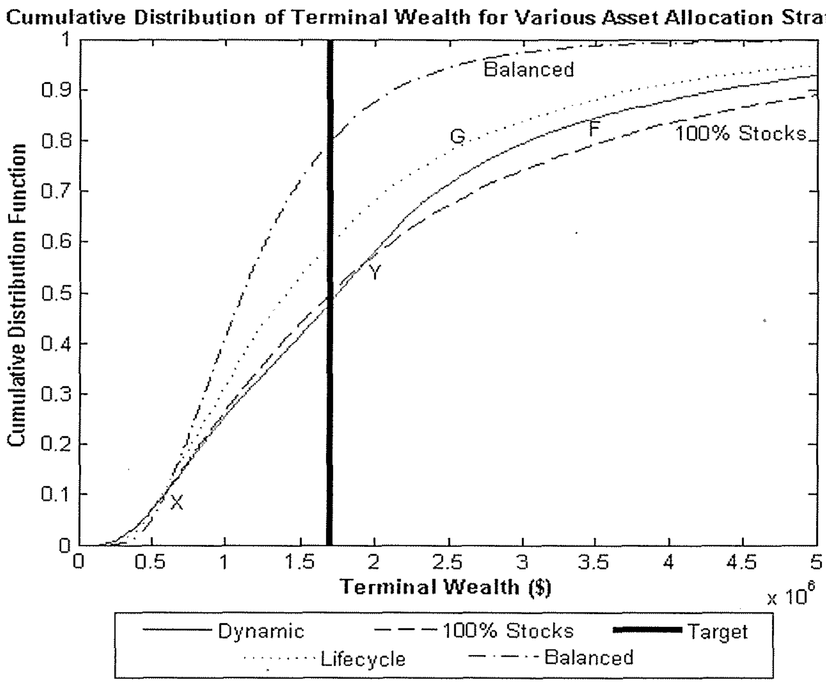
In contrast, we find the cumulative distribution of $DLC_{20,20}$ remains below that of the 100% stocks strategy for a much longer section (the left side of *Y*). This clearly suggests its effectiveness in reducing the risk of an investor's wealth breaching any floor level of wealth to the left of *Y*. It does much better in terms of producing superior outcomes in the below-median range, which is likely to be viewed as the zone of risk for most investors. Remarkably, it is obvious from the diagram that our hypothetical investor has a slightly higher chance of achieving the target wealth outcome of \$1.69 million by employing the $DLC_{20,20}$ instead of the 100% stocks strategy.

Now we turn our attention to Exhibit 4, which shows the cumulative wealth distribution functions for the other lifecycle and dynamic strategy pair: $LC_{30,10}$ and $DLC_{30,10}$. As before, we also show the cumulative wealth distributions for the 100% stocks and the balanced strategies. Except for a small part in the extreme lower tail of the distributions representing terminal wealth outcomes below \$500,000, the cumulative wealth distribution function of $DLC_{30,10}$ (*F*) always remains below that of $LC_{30,10}$ (*G*). As is the case with the $LC_{20,20}$ and $DLC_{20,20}$ pair, the distance between the CDF plots is larger in the middle than in the extremes. In other words, the dynamic strategy dominates the conventional strategy over a range of outcomes by a wide margin.

In relation to the target accumulation outcome of \$1.69 million at retirement, Exhibit 4 indicates that the $LC_{30,10}$ strategy would achieve this goal with about 40% certainty. Although this is a significant improvement compared to the performance of $LC_{20,20}$, it still falls short of the corresponding dynamic strategy $DLC_{30,10}$, which surpasses the target on more than 50% of occasions. The cause of the $LC_{30,10}$ strategy putting up a superior

EXHIBIT 4

Cumulative Distribution Plots for the Second Pair of Lifecycle and Dynamic Strategies ($LC_{30,10}$ and $DLC_{30,10}$)



performance relative to the $LC_{20,20}$ strategy in attaining the target may be attributed mainly to the fact that the former invests in a 100% stocks portfolio for a longer duration (30 years) compared to that of the latter (20 years). However, to apply the same argument to explain the dominance of dynamic strategies over corresponding lifecycle strategies appears too simplistic. Had this been the only reason, the 100% stocks strategy would have outperformed other strategies in terms of exceeding the target accumulation. But as is evident from Exhibit 4, the probability of achieving the target wealth outcome with the $DLC_{30,10}$ strategy is clearly higher than that with the 100% stocks strategy. Also, the median outcome for the $DLC_{30,10}$ strategy is larger than that of the 100% stocks strategy.

To find out whether dominance by ASD exists between different strategies, we calculate the values of ε and provide the results in Exhibit 5. There is strong evidence to suggest that $DLC_{20,20}$ dominates $LC_{20,20}$ under ASD because ε is 0.0067, which is far less than our threshold area of violation of 1%. Similarly, $DLC_{20,20}$ dominates the balanced strategy with the value of ε being 0.0068, but it does not dominate the 100% stocks strategy under ASD criterion. The 100% stocks strategy also clearly dominates the lifecycle and the balanced strategies with even lower values of ε in both cases. There is no ASD over the dynamic strategy at our set threshold ε of 1%. This result would change if the threshold is set somewhat higher, say, at 5%, because the 100% stocks strategy produces some spectacularly high simulation outcomes that increase the area of non-violation, thereby reducing the value of ε when measuring its dominance over others.

For the dynamic and lifecycle strategy pair commencing the switch after 30 years, the results are shown in Panel B of Exhibit 5. For $DLC_{30,10}$ and $LC_{30,10}$, the evidence for ASD in favor of the former is even stronger than that in the other pair with ε of 0.0072. Similarly, the dominance over the balanced portfolio is also slightly stronger with the ε value in this case being 0.0058. As expected, the 100% stocks strategy also dominates both the lifecycle and the balanced strategies. Comparing $DLC_{30,10}$ and the 100% stocks strategy, neither of the strategies dominates the other although the values of ε indicate that the 100% stocks strategy comes close to having ASD over the dynamic strategy. Again, this is clearly a result of the 100% stocks strategy beating the other strategies by wider margins as we move towards the right end of the distribution.

But what is the success (or failure) rate of the dynamic strategy over other strategies in different possible future states of the world? This knowledge is important to the investor, yet comparing probability distributions of terminal wealth under different competing strategies does not provide a clear answer. This is because in doing so we are comparing the *n*th percentile outcome of one strategy with the *n*th percentile outcome of the other. In other words, the good scenarios under one strategy

EXHIBIT 5
Almost Stochastic Dominance Results for Dynamic Strategies

Strategy	Area of SD Violation Relative to Non-violation (ε)			
Panel A				
	Lifecycle ($LC_{20,20}$)	Balanced	$DLC_{20,20}$	100% Stocks
Dynamic ($DLC_{20,20}$)	0.0067*	0.0068*	–	0.9624
100% Stocks	0.0039*	0.0046*	0.0375	–
Panel B				
	Lifecycle ($LC_{30,10}$)	Balanced	$DLC_{30,10}$	100% Stocks
Dynamic ($DLC_{30,10}$)	0.0072*	0.0058*	–	0.9424
100% Stocks	0.0092*	0.0046*	0.0575	–

**Almost Stochastic Dominance exists for the threshold value $0 < \varepsilon < 1$.*

are compared to the good scenarios under another and, likewise, the bad outcomes are pitted against the bad outcomes. But for any particular future state of the world (with a particular asset return path over the investment horizon), this comparison may not be very useful. For example, if stock returns turn out to be very poor compared to other assets in a particular state of the world, the 100% stocks strategy would produce an inferior outcome relative to a balanced strategy no matter how attractive or dominating the wealth distribution of the former appears compared to the latter.

Recall that the asset-class return path over the 41-year horizon is unique for each trial in our simulation experiment. Each of the 10,000 trials represents a different possible future state of the world. Therefore, for each trial, we compare the wealth outcomes under all four strategies, the main point of interest being how the dynamic strategy perform vis-à-vis other strategies. To be specific, we compute the shortfall probability of $DLC_{20,20}$ and $DLC_{30,10}$ as well as their average size of shortfall compared to the other three strategies. The shortfall measures are likely to constitute an important part of what investors view as the downside risk of adopting the dynamic allocation strategy. The results, provided in Exhibit 6, show that the dynamic strategy has a small chance of underperforming the conventional lifecycle strategy. The wealth outcome of the dynamic strategy $DLC_{20,20}$ falls short of that of the corresponding lifecycle strategy $LC_{20,20}$ in only 19% of trials. The chance of $DLC_{30,10}$ underperforming the corresponding lifecycle strategy $LC_{30,10}$ increases, however, to 26% (i.e., one in four). But the average size of the shortfall in both cases is small—$34,462 and $50,273—compared to the average size of terminal wealth outcomes, which run into millions.

EXHIBIT 6

Shortfall Measures of Dynamic Strategies Relative to Other Asset Allocation Strategies

Strategy	Shortfall Probability	Average Shortfall ($)
$DLC_{20,20}$		
Lifecycle ($LC_{20,20}$)	19%	34,462
100% Stocks	51%	582,815
Balanced	10%	6,110
$DLC_{30,10}$		
Lifecycle ($LC_{30,10}$)	26%	50,273
100% Stocks	43%	343,890
Balanced	11%	6,907

Note: Results are based on 10,000 simulations.

Further comparing individual trial outcomes, we find that the $DLC_{20,20}$ strategy gives the 100% stocks strategy a close run. The chance of doing better with either strategy is *almost* even with the 100% stocks strategy emerging the winner in 51% of the trials. But when compared with $DLC_{30,10}$, the 100% stocks strategy fares better only in 43% of trials (i.e., the dynamic strategy emerges the winner in a majority of cases). The average size of the shortfall for the dynamic strategy in both cases, however, is quite high at $582,815 and $343,890, respectively. This is not unexpected with the 100% stocks strategy producing several spectacularly large wealth outcomes in the above-median range and particularly in the upper quartile. Relative to the balanced strategy, the chance of underperformance of the dynamic strategy is minimal. The $DLC_{20,20}$ and $DLC_{30,10}$ strategies underperform the balanced strategy only in 10% and 11% of the trials, respectively. The average size of shortfall in both cases is extremely small at $6,110 and $6,907, respectively.

While our evidence so far suggests the superiority of dynamic strategies over conventional lifecycle strategies, the saving grace for the latter may lie in the zone of the most adverse outcomes. This is represented by the left portion of X in the CDF plots in Exhibits 3 and 4 where the lifecycle strategies actually dominate corresponding dynamic strategies. It is also apparent from the figures that this zone is constituted by outcomes that are below the 10th percentile mark for every strategy. To have some idea about how large the differences are between the adverse outcomes under different strategies, we report the VaR estimates at confidence levels of 99%, 95%, and 90% for both sets of simulation trials in Exhibit 7. We also estimate the expected tail loss (ETL) at a 95% confidence level, which is essentially a probability weighted average of all below-VaR outcomes at that specified level of confidence.

As is evident in the CDF plots, both the lifecycle strategies, $LC_{20,20}$ and $LC_{30,10}$, produce 95% and 99% VaR estimates that are higher compared to their dynamic counterparts (the balanced and 100% stocks strategy). The differences between the 95% VaR estimates (less than $25,000) do not appear to be large enough to cause

EXHIBIT 7

VaR and ETL Estimates for Different Asset Allocation Strategies

Asset Allocation Strategy	VaR at Different Confidence Levels			ETL at 95% Confidence Level
	99%	95%	90%	
Panel A				
Dynamic ($DLC_{20,20}$)	275,914	461,640	607,872	344,437
Lifecycle ($LC_{20,20}$)	375,810	486,156	578,814	417,804
100% Stocks	271,458	447,330	592,348	337,980
Balanced	361,326	505,209	597,506	422,350
Panel B				
Dynamic ($DLC_{30,10}$)	274,968	444,468	599,673	340,901
Lifecycle ($LC_{30,10}$)	321,875	468,598	581,526	377,114
100% Stocks	274,657	443,251	595,398	339,980
Balanced	369,362	501,541	599,863	423,124

Note: All values in nominal dollars.

concern. But when the 99% VaR estimates are compared, the differences between the lifecycle and the dynamic strategies grow considerably larger. The estimated 99% VaR estimate for the $LC_{20,20}$ strategy is almost \$100,000 more than that of the corresponding dynamic strategy $DLC_{20,20}$. Between $LC_{30,10}$ and $DLC_{30,10}$, the corresponding difference, however, is smaller than \$50,000.

Yet one would be reluctant to declare lifecycle funds to be the preferred investment strategy even under the assumption that investors care only about the zone of extremely adverse wealth outcomes (below the 10th percentile in this case). This is because the balanced fund produces a better 95% VaR estimate than both $LC_{20,20}$ and $LC_{30,10}$. In terms of 99% VaR estimates, the balanced fund outperforms $LC_{30,10}$, but underperforms $LC_{20,20}$. When we consider the average for all outcomes below 95% VaR estimates, the balanced fund produces ETL estimates that are higher than both $LC_{20,20}$ and $LC_{30,10}$. These results suggest that if the retirement plan investors are concerned about improving the floor level of possible wealth outcomes or protection from extreme downside risk, they would be better off by investing in a static balanced fund rather than a conventional lifecycle fund.

How sensitive are our results to the target return used by the dynamic strategies to switch allocations? Recall that both the dynamic strategies in our study that use a switching rule are based on a target return of 10% on investment. Repeating the simulation trials using target returns in the 8%–12% range, we do not find any evidence of the dominance of the dynamic strategies over corresponding lifecycle strategies (and the balanced strategy) disappearing at all.[9] An increase in target return leads to a slightly higher chance of the dynamic strategy underperforming the lifecycle strategy. For example, when the target rate of return is set at 12%, the shortfall probability of the dynamic strategy $DLC_{20,20}$ relative to lifecycle strategy $LC_{20,20}$ is just 1% higher than the shortfall probability with the target return set at 10%. The corresponding increase in average shortfall of $DLC_{20,20}$ is also very small (less than \$5,000). Similarly, a decrease in target return results in a very small reduction in the shortfall probability of the dynamic strategies. The estimates of ASD for simulations with these different target returns are remarkably similar to those with a 10% target rate of return.

Another interesting point revealed by the sensitivity analysis is that as the target rate increases, the median outcome of the dynamic strategy continues to outperform that of the 100% stocks strategy by an even larger margin, and vice versa. The higher target also enables the dynamic strategies to close the gap with the 100% stocks strategy in terms of mean and third-quartile estimates. But by setting a higher return target, the dominance of the first-quartile outcome of the dynamic strategy over the corresponding outcome of the 100% stocks strategy is diminished considerably. In fact, $DLC_{30,10}$ actually produces a lower first-quartile result than the 100% stocks strategy when the target rate for switching is set to 12%. Similarly, the dominance of dynamic strategies over the 100% stocks strategy for more inferior (below first quartile) outcomes is also adversely affected by raising the target rate for switching.

Our findings are as would be expected—the higher the target rate is set, the higher is the likelihood that the accumulation at any point will fall below the target, thereby prompting the dynamic strategy to remain invested in equities. As a result, the behavior of the dynamic strategy would closely follow that of the 100% stocks strategy. The outcomes in the above-median range will get better, but outcomes in the below-median and below-first-quartile range would become marginally poorer. But if the target rate is set lower, there is a higher likelihood that the retirement account balance would cross the accumulation target at any point, thus triggering the dynamic strategy to shift allocation towards bonds and cash. This, in turn, would cause the strategy to closely resemble a conventional lifecycle strategy.

CONCLUSION

The evidence presented in this article exposes the inherent weakness of traditional lifecycle investing for members of retirement plans. By blindly switching to conservative assets in the later part of the accumulation phase of retirement saving, lifecycle funds seem to be missing a trick. Although switching out of volatile assets, such as stocks, as the plan member nears retirement is generally accepted as sensible investment advice, traditional lifecycle funds implement this strategy in a dogmatic manner that appears to disregard the investors' wealth accumulation objectives.

As we have demonstrated, the mechanistic switching strategy from growth to conservative assets following any age-based rule of thumb is inferior to a dynamic strategy that considers the actual accumulation in the retirement account before switching assets. We have proposed a specific dynamic asset allocation strategy in which the switching of assets at any stage is based on the cumulative investment performance of the portfolio relative to the investors' target at that stage. Unlike conventional lifecycle asset allocation rules where the switching of assets is preordained to be unidirectional, this dynamic strategy can switch assets in both directions—from aggressive to conservative, and vice versa. Using the simple rule of Almost Stochastic Dominance, we show that such a dynamic lifecycle strategy would be preferred to the conventional lifecycle strategy by most retirement plan members.

When comparing percentile outcomes in our trials, the only occasion when we find lifecycle strategies do better than the dynamic strategies is in outcomes below the 5th–10th percentile range. However, the differences do not appear to be large enough to negate the appeal of dynamic strategies to the average investor in view of their overall dominance over lifecycle strategies. Even for the extremely adverse wealth outcomes in our trials, we find that the static balanced asset allocation strategy generally does better than the lifecycle strategy. Therefore, an investor whose sole concern is improving the floor level of the extremely adverse wealth outcomes is likely to prefer investing in a balanced fund rather than in a lifecycle fund.

We have conducted a large number of trials to capture different possibilities about future asset class returns over the investment horizon of the retirement plan investor. According to our results, the chance of the dynamic strategy underperforming the lifecycle strategy at the end of such a long horizon is small, although not insignificant. Not only does the dynamic strategy produce superior terminal wealth outcomes compared to the lifecycle strategy in a vast majority (about 75%–80%) of cases, it appears to have a fair chance of outperforming a 100% stocks strategy. In fact, the dynamic lifecycle strategy $DLC_{30,10}$, which invests in an all-equity portfolio for the first 30 years and then adjusts its asset allocation on an annual basis, seems to have more than an even chance of beating the strategy that invests in an all-equity portfolio for the entire horizon.

It is hard to imagine that most people are so pessimistic or optimistic that they care only about the extreme outcomes. Decisions in life, including investment, are typically driven by the vast middle range of possibilities. It is precisely because of this reason that the dynamic strategy looks appealing in the context of our problem. Ignoring the extremities, the dynamic strategy invariably results in much higher wealth accumulation potential compared to the conventional lifecycle strategy. Remarkably, this is achieved while reducing downside risk compared to an all-equity strategy as evidenced from the dominance of the dynamic strategy in the below-median range of wealth outcomes.

In terms of practical considerations for the implementation of the dynamic approach we have discussed in this article, an important issue is setting the target accumulation rate. If set too high, it is unlikely to be achieved, and hence the investment strategy will remain 100% stocks for most of the accumulation period. If set too low, the overall strategy may be too conservative and, in essence, is similar to the conventional lifecycle strategy. There are also behavioral considerations. The dynamic strategy will switch back from conservative to growth assets in the final phases of the accumulation period if cumulative returns are below target. This is most likely to happen following poor returns in stocks. It is likely that many unsophisticated investors, as is typical of many participants in retirement plans, will be concerned about the prospect of increasing equity risk with recent losses still fresh in the mind. Hence, the strategy may be sensible from an investment perspective, particularly if there is a degree of mean reversion in returns, but difficult psychologically. An alternative might be an asymmetric dynamic approach that "banks" excess gains, but does not increase risk when returns are below target.

Overall, it appears that dynamic lifecycle strategies that respond to achieved investment performance offer scope to improve on the lifecycle strategies currently most commonly used, which change their asset allocation based only on age. We do not suggest that the specific dynamic allocation rule we have proposed is the optimal strategy for all, or even most, retirement investors. But we do think that our evidence points towards the general approach that practitioners should consider in designing lifecycle funds for retirement plans.

ENDNOTES

[1]This is sometimes referred to as *time diversification*. Samuelson [1989] showed that if returns are independently and identically distributed such long-horizon effect cannot exist.

[2]Munnell and Sunden [2006] suggested that the typical contribution rate for a 401(k) plan member is 9%.

[3]Studies such as Lo and MacKinlay [1988] that find evidence of nonrandomness in returns mostly use high-frequency data, such as daily and weekly returns data. Poterba and Summers [1988], who found evidence of time-varying expected returns, also admitted that an insufficient number of independent observations makes it difficult to draw conclusion on return predictability in low-frequency data, such as the annual returns data used in this article.

[4]Because the distribution of wealth outcomes is increasingly asymmetric over long horizons, the mean-variance framework is not useful. We also refrain from making any strong assumption on the utility function (e.g., quadratic) of the plan members.

[5]See Levy [2006] for a review of different applications of stochastic dominance.

[6]A rule under a weaker condition called Second Degree Stochastic Dominance (SSD) is also applied to a large class of problems that works within the framework of risk aversion. Formally, given $U'(W) \geq 0$ and $U''(W) \leq 0$, F is preferred to G under SSD criterion if, and only if,

$$\int_0^\infty F(W)dW \leq \int_0^\infty G(W)dW \quad \forall W$$

This implies that the area under F has to be equal or less than the area under G for the dynamic strategy for every W to dominate the conventional strategy by the SSD rule.

[7]Take, for instance, the case in which an investor faces a choice between two uncertain prospects: a certain outcome X returning \$1 and an uncertain outcome Y returning \$100,000 with a probability of 0.99 or \$0.9 with a probability of 0.01. Although it is practically inconceivable that any investor would not prefer F over G, under both FSD and SSD conditions Y does not dominate X. The reason for this perverse result is that the stochastic dominance approach relates to *all* utility functions in a given class and therefore does not rule out extreme utility functions that provide higher expected utility under X.

[8]Recently, Bali et al. [2009] employed the ASD approach in the context of lifecycle asset allocation.

[9]Results of the sensitivity analysis trials are available from the authors on request.

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Retirement Adequacy Through Higher Contributions: *Is This the Only Way?*

MICHAEL DREW, PIETER STOLTZ, ADAM WALK, AND JASON WEST

MICHAEL DREW
is a professor in the Department of Accounting, Finance and Economics in Griffith Business School, Griffith University at Queensland, Australia.
michael.drew@griffith.edu.au

PIETER STOLTZ
is a researcher in the Department of Accounting, Finance and Economics in Griffith Business School, Griffith University at Queensland, Australia.
pieter.stoltz@uqconnect.edu.au

ADAM WALK
is a research fellow in the Department of Accounting, Finance and Economics in Griffith Business School, Griffith University at Queensland, Australia.
a.walk@griffith.edu.au

JASON WEST
is an associate professor of the School of Business and Law at Central Queensland University at Queensland, Australia.
j.m.west@cqu.edu.au

In 1992 Australia introduced a mandated system of retirement savings based on hard compulsion, known as the Superannuation Guarantee (SG). Under the SG, employers are required to make tax-deductible superannuation contributions for their employees. Despite this being a relatively inclusive and comprehensive retirement savings system, serious concerns over the retirement adequacy of Australian workers remain. In an effort to combat the pension liability of an aging population, exacerbated by increased life expectancy and rising health care costs, in 2012 the Commonwealth Government of Australia proposed to gradually increase the SG from 9% of workers' earnings to 12% over a seven-year period (see Exhibit A1 in the Appendix for the schedule of rate increases). A 12% SG is expected to improve the standard of living of Australian retirees.

While simply increasing the compulsory level of savings may seem like a straightforward solution to improving retirement adequacy, added contributions are not without cost. A major risk facing workers is an unfavorable sequence of returns in the years immediately prior to retirement. Unfavorable path dependency of portfolio returns, or "sequencing risk," is recognized as a key risk facing the retirement portfolios of workers. The effect of sequencing risk increases with the size of the retirement savings portfolio, and for most workers is greatest in the decade immediately prior to retirement. Coupled with a suboptimal asset allocation strategy, the sequencing risk exposure of a larger portfolio represents a significant risk to the retirement portfolio of most workers under both a 9% SG and a 12% SG. It should be noted that while a disappointing result can undoubtedly reflect sequencing returns, it can also reflect a low geometric average return that is independent of how the returns are sequenced. In relation to increasing the SG, sequencing risk can undo, at least to some extent, the positive effects of a higher contribution rate on retirement security.

In this study we compare the old 9% SG with the 12% SG. We show that the retirement adequacy of workers could be more simply improved through investment strategy design that mitigates sequencing risk rather than a broad-based increase in the contribution rate.

We use long-horizon historical returns data from various asset classes to simulate retirement outcomes of workers investing in typical asset allocation strategies. In contrast to using a single rate of return on retirement savings to model a single wealth outcome at retirement (Bateman and Piggot [1993]), we use Monte Carlo, bootstrap simulation, and stationary bootstrap simulation techniques to model accumulation paths based on historical returns to derive a distribution of terminal wealth outcomes, defined as the workers' portfolio value immediately prior to retirement. To investigate the virtues of arbitrarily increasing contributions to pension portfolios we use the retirement wealth ratio (RWR) and the associated income replacement rate (RR) as success measures. The RWR is the ratio of terminal wealth to final salary, while the RR is the retiree's annual withdrawal rate as a proportion of salary immediately prior to retirement. For the purpose of this study, these measures relate to the worker's compulsory retirement savings under the SG only. They do not include any other sources of retirement income, such as the Age Pension or voluntary contributions, on the basis that the SG has become the main determinant of retirement adequacy for the bulk of middle class Australians (Bateman and Piggot [1993]).

The simulation results show that increasing the contributions of workers without appropriately altering the asset allocation strategy of such investments will continue to expose workers to sequencing risk that may undermine the objectives of the pension increase. In particular, asset allocation strategies with a higher proportion of stocks are shown to be more suitable for achieving adequate retirement outcomes for workers invested in the "default" superannuation asset allocation option without the need for increased contributions. To counter the sequencing risk experienced by workers contributing a greater proportion to superannuation under revised SG provisions, we examine the effectiveness of competing asset allocation styles within the default option to offset this risk. Despite the higher volatility experienced in the portfolio, we find that increasing the allocation to stocks actually reduces the risk of workers experiencing adverse retirement outcomes in the accumulation phase of defined contribution (DC) superannuation plans. These results highlight that retirement adequacy can be improved through optimal investment strategy design rather than arbitrarily increasing contribution rates.

RETIREMENT ADEQUACY AND SUPERANNUATION POLICY

Retirement policy in Australia was designed as a three-pillar system: the age pension, the SG, and voluntary retirement savings (Piggott et al. [2001]). For the majority of workers, mandatory contributions under the second pillar are seen as the critical component aimed at reducing the dependency of future retirement benefits on the government. Under the superannuation reforms in Australia in 2011/12, collectively known as the Stronger Super reforms, employers must channel mandated contributions only to low management expense ratio (MER) products with a single investment option. These low-cost default funds are officially authorized as "MySuper" products. The majority of workers do not deviate from the employer default fund (Commonwealth Treasury [2013]) and, although the reforms acknowledge the importance of the default asset allocation strategy, the superannuation legislation does not mandate a retirement income scheme, only an accumulation profile. Superannuation funds are not directly rewarded for maximizing the terminal wealth of their members or ensuring that the level of wealth is "adequate" for retirement.

Defining a level of wealth that is deemed "adequate" is not simple. Since the retirement adequacy for most retirees depends on their desired lifestyle during retirement, a number of criteria need to be met. To better define adequacy, some scholars employ a preference-based calibration approach that uses constant relative risk aversion utility or constant absolute risk aversion utility to define retirement adequacy (Hurd and Rohwedder [2003]; Scholz et al. [2004]; Poterba et al. [2006]). These approaches have had very limited success.

A number of competing measures of retirement adequacy are based on terminal wealth. Terminal wealth is easy to operationalize and enables analysis of retirement outcomes using a range of evaluation criteria. More importantly, the terminal portfolio balance represents the single most important objective that defined contribution (DC) scheme members aim to achieve immediately prior to retirement. An alternative but related measure of retirement adequacy is the income replacement rate (RR). The RR provides a target that is expressed as the annuity equivalent value of retirement wealth as a fraction of a person's salary in the final year of employment. This measure is popular in the literature because it is very likely that people's post-retirement expectations are closely linked to their pre-retirement income (Palmer [1994]; Moore and Mitchell [1997]). An income replacement rate of 65%-75% is commonly assumed for Australian workers and is comparable to international rates (Binswanger and Schunk [2012]). Also derived from terminal wealth is the retirement wealth ratio (RWR), which is a useful measure of adequacy because it frames the retirement target as the ratio of terminal wealth to final annual salary (Booth and Yakoubov [2000]). These benchmarks are accessible to the individual because they relate their retirement savings to their standard of living.

Portfolio Size Effect, Sequencing Risk, and Asset Allocation

Of great concern among workers in the accumulation phase of DC superannuation plans prior to retirement is the portfolio size effect and the related phenomenon of sequencing risk. In the early years of a worker's retirement savings plan, contributions account for the majority of the portfolio. However, as the returns on past contributions accumulate to become the main driver of terminal wealth, incremental contributions become less important, although many workers do make additional contributions as they approach retirement. The relationship between contributions and returns over time is the source of the portfolio size effect, which has been explored in Basu and Drew (2009).

Sequencing risk is the risk of experiencing returns in an unfavorable order during periods in which there are capital changes to the portfolio. Conversely, a favorable sequence of returns can result in "good" sequencing risk (Frank and Blanchett [2010]; Frank et al. [2011]). Sequencing risk is highly relevant to the issue of retirement adequacy because a large market downturn occurring close to retirement could deplete a worker's retirement nest-egg to the point where it may never recover.

Modern portfolio theory (MPT) assumes that wealth is a function of a series of time-weighted returns (Markowitz [1952]). This only holds in the rare case of an initial endowment with no subsequent changes in capital. The presence of continual contributions and withdrawals to and from a retirement savings plan is a major determinant of workers' wealth. This forms a set of dollar-weighted returns from which the investment's internal rate of return (IRR) may be derived. Dollar-weighted returns are intuitive to many workers but the concept rarely appears as a performance objective in portfolio management. MPT ignores the sequence of returns, which can substantially affect the terminal wealth of a retirement portfolio. The ability of superannuation portfolios to achieve a dollar-weighted return target relies not only on the contributions into the portfolio (and withdrawals out of the portfolio), but also on the allocation of the assets in the portfolio, the changes in asset allocation through workers' lives, and the sequence of returns.

Default Asset Allocation Plans

Default investment options that maintain a constant proportion of asset classes, known as target risk funds (TRF), assume that workers have an infinite investment horizon and maintain complete flexibility over their retirement date. Target risk funds (TRFs) attempt to maintain the same level of risk through time by holding a constant proportion of growth and defensive assets. TRFs are commonly employed in MySuper products at varying proportions of growth and defensive assets. TRF strategies can range from a 100% stocks to 100% cash strategy. In addition to these two extremes, in this study we consider growth/defensive asset splits of 50/50 (moderate TRF portfolio), 60/40 (default option average (DOA) TRF portfolio), and 70/30 (balanced TRF portfolio). We have elected to label each growth/defensive split in this way to provide a familiar description. In reality, the growth/defensive split that constitutes moderate or balanced often varies among superannuation funds (Gallery et al. [2004]).

Since workers generally have a finite investment horizon, target date funds (TDF) have since emerged. TDFs switch from growth to defensive assets according to a pre-determined glidepath as a worker approaches retirement. TDFs reduce the proportion of growth assets in the retirement portfolio as the worker approaches a retirement date using deterministic switching rules. TDFs have become a core product for investors saving for retirement, particularly in the U.S. (Estrada [2014]). But while lifecycle strategies implied in TDFs attempt to address the issue of a finite investment horizon, they are unable to appropriately position workers' retirement investments to achieve a defined adequacy target. In the case of deterministic asset allocation strategies such as TRFs and TDFs, the asset allocation strategy may become inconsistent with an individual's investment objective over time without corrective action.

Portfolio adequacy based on a defined terminal wealth target can be better achieved by using target-driven asset allocation strategies such as a dynamic lifecycle strategy (DLC) strategy. The DLC strategy increases the allocation to riskier asset classes when workers' portfolio wealth is less than a defined adequacy target. The adequacy target could be defined in a number of ways, such as a target based on terminal wealth only or an income replacement rate or, as is the case in this study, a retirement wealth ratio. The glidepath of a DLC strategy is not pre-determined, because the asset allocation policy is not only dependent on a worker's retirement date but also on the performance of the portfolio relative to a retirement target. When the portfolio wealth is greater than an adequacy target the allocation shifts toward more defensive assets, and when wealth falls below the target the portfolio shifts its weight toward growth assets. The DLC strategy is a flexible approach that preserves terminal wealth as the primary objective, particularly in the presence of sequencing risk. This approach is in sharp contrast to the static and deterministic allocation strategies of TRFs and TDFs that make terminal wealth a secondary goal behind the goal of maintaining a pre-determined policy portfolio.

We propose that simply increasing the SG provision alone may not materially improve retirement adequacy for all DC plan members, especially considering the cost of forgone consumption associated with increased contributions that are being exposed to sequencing risk. Using a suite of robust simulation approaches, we consider the practical implications of an increase in the SG contribution rate and its impact on retirement adequacy.

METHODOLOGY AND DATA

The model used to generate terminal wealth outcomes is

$$TW = k\sum_{t=0}^{n-1} S_t(1+r_t)\prod_{u=t+1}^{n-1}(1+r_u) \quad (1)$$

where TW is the terminal value of retirement wealth, k is the plan contribution rate, r_t is the nominal rate of investment return earned in year t and r_u is the nominal rate of return in year $t-1$, and n is the number of years before retirement. S_t is the annual salary in year t and is given by $S_t = S_0(1+g)^{t-1}$, where S_0 is the starting salary and g is the nominal salary growth rate. From Equation (1) it is clear that the contribution rate as determined by workers' salaries through their lives, the investment horizon, and the asset allocation are the three main factors affecting retirement adequacy. While the investment horizon critically impacts a worker's retirement adequacy, we exclude its impact in this analysis because few workers have much flexibility in choosing their retirement date. Analyzing the effect of investment horizon on portfolio outcomes has been considered in other analyses (Hickman et al. [2001]) but for model tractability we maintain a constant investment horizon.

For the simulation we use a monthly contribution model in line with the SG provisions that mandate at least a quarterly contribution frequency. We examine two competing SG contribution rate scenarios: the old minimum rate of 9% and the new minimum rate of 12%. These rates are kept constant over the entire investment horizon so as to compare outcomes under each contribution regime. We also assume that the employee is fully employed during the entire investment horizon and hence contributions are a constant percentage of salary over time. Exhibit 1 outlines the basic simulation model inputs. Values are represented as Australian dollars

EXHIBIT 1
The Hypothetical Worker

Input	Value
Starting balance	AU$0
Age entering workforce	25
Age at retirement	65
Investment horizon	40
Starting salary	AU$55,000
Salary growth rate	4%

Note: Hypothetical worker's wage profile and investment period. The starting salary of AU$55,000 is in line with the starting salary of Australian university graduates (Australian Bureau of Statistics [2013]). The salary growth rate of 4% per year represents an estimate of inflation and some productivity gains to the employee.

EXHIBIT 2
Target Risk Funds—Growth/Defensive Splits

Age	100% Cash	Moderate	DOA	Balanced	100% Stocks
25 to 65	0/100	50/50	60/40	70/30	100/0

Note: Growth/defensive splits for the five TRFs through the investment horizon, which is given by the worker's age.

(AU$) throughout the remainder of the analysis but will be referred to only as dollars.

We examine seven asset allocations: the five target risk funds (TRFs), one target date fund (TDF), and one dynamic lifecycle fund (DLC). The growth/defensive split for each asset allocation through the hypothetical worker's life is shown in the following tables. Exhibit 2 shows that for the TRFs the proportions of growth and defensive asset classes remain unchanged during the investment period.

TDFs have deterministic glidepaths. The asset class proportions depend only on the worker's retirement date and the glidepath algorithm. We consider one TDF strategy with a glidepath that is a reasonable representation of the TDF strategies employed by superannuation funds. As Exhibit 3 shows, this TDF invests 80% in growth assets and 20% in defensive assets for the first 20 years of the investment period before commencing a linear switch from growth to defensive assets. The final asset allocation proportions were set at 56% growth assets and 44% defensive assets. Hence if the switch from growth to defensive assets commences in the 21st year of the strategy, the glidepath algorithm reduces growth assets by 1.2% per year for the next 20 years until retirement date.

The DLC strategy is partitioned into three investment periods, as can be seen in Exhibit 4. For the first 30 years the strategy invests in growth assets only, so that Australian stocks and U.S. stocks each comprise half of the portfolio. The rationale for the initial 100% allocation to growth assets only is that the objective of the worker is to maximize wealth over the first 30 years of the investment horizon. Consistent with lifecycle theory, the worker should have sufficient time to recover wealth in the final 10 years if stock market performances have been unfavorable.

EXHIBIT 3

Target Date Fund—Growth/Defensive Splits

Age	TDF
25 to 45	80/20
46 to 64	changing linearly from 80/20 to 56/44
65	56/44

Note: Growth/defensive splits for the TDF through the investment horizon, which is given by the worker's age.

EXHIBIT 4

Dynamic Lifecycle Fund—Growth/Defensive Splits

Partition	Age	DLC
1	25 to 55	100/0
2	56 to 60	If $RWR_t > RWR_{target}$ then 80/20 If $RWR_t < RWR_{target}$ then 100/0
3	61 to 65	If $RWR_t > RWR_{target}$ then 60/40 If $RWR_t < RWR_{target}$ then 100/0

Note: Growth/defensive splits for the DLC through the investment horizon, which is given by the worker's age.

The remaining two partitions are each five years in length and have slightly different asset allocation rules. For both partitions, the below-target portfolio is 100% in growth assets. The above-target portfolio in the second partition is 80% in growth assets and 20% in defensive assets. The above-target portfolio in the third and final partition is 60% in growth assets and 40% in defensive assets. The rationale for the decreasing proportion of growth assets in the above-target portfolios in each of the final two partitions is to reduce risk when the worker approaches retirement, so long as the worker remains above this target.

The DLC is a different lifecycle model to the TDF for two reasons. Firstly, the DLC strategy uses performance feedback to control the asset allocation at any point in time while the TDF does not. Secondly, the DLC invests in 100% growth assets for 10 years longer than the TDF before the switching rules take effect.

The following asset allocation assumptions were made. A 5% allocation to cash (Australian T-bills in our empirical analysis) is always maintained if an asset allocation strategy is invested in defensive assets, except for the 100% cash strategy. The remaining proportion of any allocation to defensive assets is made to Australian bonds. Where an asset allocation strategy is invested in growth assets, half of the proportion of growth assets is allocated to Australian stocks and half is allocated to U.S. stocks.

Data

We use monthly returns data of four asset classes obtained from the Global Financial Database. Nominal returns, including periodic cash flows such as dividends, for Australian Stocks, U.S. Stocks, Australian Bonds, and Australian T-bills from October 1882 to February 2013 are used as the basis for the simulation. The Global

Financial Database adjusts returns data for survivorship bias. The use of monthly returns in this study replicates the monthly contribution frequency typical for most workers who contribute to a superannuation plan.

In this study, all asset class returns are in Australian dollar terms. The Global Financial Database uses exchange rate data to convert the returns for U.S. stocks from U.S. dollars to Australian dollars so the hypothetical worker is exposed to foreign currency risk over the investment period. While an investigation into the impact that hedging this foreign currency risk would have on retirement outcomes is beyond the scope of this study, we acknowledge that hedging might provide retirement outcomes that differ substantially from the unhedged retirement outcomes of this study.

We recognize the issue of the purchasing power of a worker's retirement savings through the use of the retirement wealth ratio (RWR), which anchors terminal wealth to the price level of the year in which workers receive their final salary. We use Australian stocks and U.S. stocks as proxies for growth assets and Australian bonds, and Australian T-bills as proxies for defensive assets. While an international fixed interest asset class may comprise a share of retirement products in practice, we exclude these based on the reasoning that the majority of bond investments in default investment options are domestic (Morningstar [2013]).

Descriptive statistics of the returns data for each of the four asset classes used in this study are presented in Exhibit 5. For tax considerations, in Australia mandatory contributions, but not retained earnings, are taxed at 15%, and discretionary contributions in addition to the mandatory payments made during the accumulation phase are taxed at the investor's marginal tax rate. In general there is no taxation of earnings or contributions beyond the age of 60. For simplicity the values obtained in this analysis exclude the effect of taxation on mandatory contributions as well as after-tax discretionary contributions.

Simulation

We model using both parametric and non-parametric simulation methods to generate 10,000 accumulation paths for each asset allocation from historical data. We selected three simulation methods to test for the robustness of results: Monte Carlo, standard bootstrap, and stationary bootstrap.

First, the Monte Carlo simulation draws returns from a normal distribution with a mean and standard deviation calibrated to the historical data. Although the Monte Carlo method is a versatile simulation technique, it assumes returns are Gaussian, it departs from the time characteristics of the historical data, and a basic application of it generally fails to maintain cross-correlation between asset classes.

Second, the standard bootstrap process randomly resamples row vectors with replacement (Efron [1979]). This process generates 10,000 simulated 480-month-long return paths from the underlying data series. This approach does not impose distributional assumptions and maintains historical cross-correlations between asset

EXHIBIT 5
Descriptive Statisitcs of Monthly Returns Data

	Australian Stocks	U.S. Stocks	Australian Bonds	Australian T-bills
Median (%)	1.11	0.86	0.36	0.28
	(13.2)	(10.32)	(4.32)	(3.36)
Mean (%)	1.02	0.88	0.50	0.35
	(12.24)	(10.56)	(6.00)	(4.20)
Standard Deviation (%)	3.77	5.10	2.28	0.29
	(13.06)	(17.67)	(7.90)	(1.01)
Skewness	−0.84	1.01	0.59	1.77
Kurtosis	13.98	11.67	13.65	3.14
Range (%)	65.30	72.16	34.93	1.55
Minimum (%)	−42.13	−23.63	−13.47	0.06
Maximum (%)	23.16	48.53	21.47	1.62
Jarque-Bera test statistic	1,2837	9,080	12,160	1,459

Note: Descriptive statistics of the monthly returns data for Australian stocks, U.S. stocks, Australian bonds, and Australian T-bills. The median, mean, and standard deviation include annualized figures in brackets.

classes. It does not, however, preserve the time series characteristics of the data.

Third, we use the stationary bootstrap proposed by Politis and Romano [1994]. This is similar to the Efron [1979] bootstrap in the sense that it does not impose distributional assumptions on the data. It also retains cross-correlations between the returns of different asset classes and incorporates the time series characteristics of the data by resampling blocks of returns. The block length is randomly sampled from a geometric distribution and is based on the original block bootstrap method introduced by Kunsch [1989].

In the absence of a random block length this method requires the arbitrary specification of a fixed block length in practical settings (Bühlmann, [2002]). This simulation method is stationary because, by statistical inference, a moving block length permits the synthetic time series to be stationary; however, this is conditional on the underlying data being stationary as well. This feature allows the simulation to retain some of the serial dependence in the data while still generating the synthetic time series needed for our analysis.

Terminal Wealth Evaluation Criteria

We set the investment objective RWR target (RWR_{target}) based on a nominal return target of 7% per annum. This is based on a typical superannuation fund objective of the average inflation rate (represented by the consumer price index or CPI) plus 400bps. Target returns that are too high or too low are unsuitable for use in DLC strategies because the dynamic switching capability is compromised. Under the 9% contribution profile, the RWR_{target} that is equivalent to the compounded accumulation of a fund achieving a 7% annual return over the investment horizon is 6.95 times final salary. Under the 12% contribution profile, the RWR_{target} is 9.27 times final salary. The use of a common return target adjusts for different expected levels of terminal wealth because of different contribution levels.

While standard deviation is a useful measure of variability, for the RWR distributions we also use the lower partial moment (LPM) which represents downside risk for different levels of risk aversion (Bawa [1975] and Fishburn [1977]). The LPM is given by:

$$LPM_{\lambda} = \frac{1}{n}\sum_{t-1}^{n} Max\,[0,(RWR_{target} - RWR_T)]^{\lambda} \qquad (2)$$

where RWR_{target} is the target outcome (determined above), RWR_t is the outcome for the t-th observation (t–1, …, n), n is the number of observed RWR model outcomes, and λ is a parameter representing the order of the LPM, which can be calibrated to the risk aversion of the participant. We consider three LPM order parameters in the empirical analysis: $\lambda = 1$ is the probability of falling short of the $RWR_{target}(LPM_{FS})$, $\lambda = 2$ is the magnitude of the shortfall below $RWR_{target}(LPM_{MS})$, and $\lambda = 3$ is the below-RWR_{target} semi-variance (LPM_{SV}). These are standard assignments used in distributional analysis (Fishburn [1977]).

We also use the Sortino ratio, which is a reward-to-risk measure that does not penalize performance for volatility above the target outcome (Sortino and Price [1994]). The Sortino ratio is given by:

$$Sortino\ Ratio = \frac{\overline{RWR_T} - RWR_{target}}{[LPM_2]^{1/2}} \qquad (3)$$

where $\overline{RWR_T}$ is the mean RWR, RWR_{target} is the target outcome, and LPM_2 is the second lower partial moment as defined above. An extension of this measure is the upside potential ratio (UPR), which combines upside potential and downside risk (Sortino et al. [1999]) and is given by:

$$UPR = \frac{\frac{1}{n}\sum_{t-1}^{n} Max\,[0,(RWR_T - RWR_{target})]}{[LPM_2]^{1/2}} \qquad (4)$$

The numerator is the first upper partial moment and the denominator is the second lower partial moment using RWR_{target}. This measure allows us to consider the above-RWR_{target} outcomes adjusted for downside risk.

RESULTS

We conducted the simulations using all three methods as discussed above. However in the following results we focus only on the stationary bootstrap method for brevity. Here we only report on results that use the stationary bootstrap, because where the block size is random the results are less sensitive to block size misspecification than other methods (Politis and Romano [1994]). The full results are presented in the Appendix.

RWR Distributions

The distribution of retirement outcomes must be considered when investigating retirement adequacy, not just average outcomes. Exhibit 6 presents the distributional statistics of the RWR for a 9% and 12% SG contribution rate. The median adequacy shows that, as expected, increasing contributions by one-third results in a one-third increase in the median RWR. This is equivalent to an additional \$211,000 in retirement savings measured in nominal terms. Terminal wealth has increased by 4.15 times final salary, which equates to about \$1.124M in nominal terms. Considering those outcomes in the tails of the RWR distributions, in addition to the central outcomes, provides more insight into what increasing the SG provision means for plan members in terms of potential retirement outcomes. These results are in line with those of Bateman and Piggot [1993].

Increasing the SG contribution rate increases the mean, median, and range of the RWR distribution. For RWR outcomes on the lower end of the distribution, the absolute increase in retirement outcomes is more modest. Using an RWR of 10 (the 65% RR equivalent) as a benchmark that is useful for comparison, it is evident that the 25th percentile has been shifted above this level. Overall it appears that increasing the SG contribution rate is effective in boosting many plan members above this adequacy threshold. Based on this finding, we reject the naïve hypothesis that increasing the contribution rate from 9% to 12% has no impact upon the retirement adequacy of workers solely contributing to a superannuation fund. Note that, theoretically, the results in the following tables should differ by a scale factor of 1.33 (12%/9%). However, the time series generated by the stationary bootstrap may generate minor departures from the theoretical scale due to sampling from the approximated geometric distribution.

Exhibit 6 shows that the one-third increase in the contribution rate is accompanied by a corresponding increase in the standard deviation of retirement outcomes. This is theoretically expected and empirically proved. However, raising the SG contribution rate, without appropriately adjusting asset allocation, also magnifies the exposure to sequencing risk. To show the real exposure to sequencing risk, Exhibit 7 also presents the lower partial moments for the 9% and 12% contribution rates using a balanced asset allocation and the appropriate RWR_{target} for each SG. Recall that the RWR_{target} is higher for the 12% SG because workers are contributing more during their lives. Using a constant RWR_{target} would not be a fair comparison because ignoring the cost of additional contributions to the worker would make the retirement outcomes under a 12% SG appear better than they actually are relative to a 9% SG.

Exhibit 7 shows that the increased risk associated with increasing the SG contribution rate is very relevant to the issue of retirement adequacy. Each measure of downside risk, relative to the appropriate targets, has increased as a result of increasing the contribution rate; however, and as expected, the change in the shortfall measure is insignificant, as is the upside potential ratio measure. Workers are 5% more likely to fall short of the retirement target, albeit a higher target, and the expected value of this shortfall has increased by 44%. The below-target semi-variance has doubled,

EXHIBIT 6
Distribution Statistics—Changing the Superannuation Guarantee

SG	Min	P25	Median	Mean	P75	Max	IQRR
9%	2.81	9.19	12.32	14.60	17.50	126.52	0.67
12%	3.60	12.14	16.47	19.32	22.94	156.68	0.66

Note: Distributional statistics for the distributions of retirement wealth ratios for changes to the Superannuation Guarantee (SG) from a 9% contribution rate to a 12% contribution rate using a balanced TRF asset allocation. The IQRR refers to the interquartile range ratio using a stationary bootstrap simulation.

EXHIBIT 7
Investigating Sequencing Risk

Contribution Rate	σ (RWR)	LPM_{FS}	LPM_{MS}	LPM_{SV}	UPR
9%	8.32	0.0792	0.0779	0.1219	22.1447
12%	11.10	0.0835	0.1123	0.2426	20.6258
Percentage Increase	**33%**	**5%**	**44%**	**99%**	**–7%**

Note: Standard deviation of RWR, lower partial moments, and upside potential ratio for the 9% SG contribution rate and the 12% SG contribution rate using a stationary bootstrap simulation.

indicating that workers are twice as exposed to downside sequencing risk. The increased risk relative to the retirement target is not entirely offset by the upside risk. The *UPR* has declined by 7% under the higher contribution rate, which confirms that simply increasing the SG contribution rate does not necessarily improve the retirement adequacy of workers. If the contribution rate and the shortfall rate both increase by 1.33, then the probability of shortfall is unaffected. Arguably, this is what the statistics for LPM_{FS} show in Exhibit 7, as the difference is insignificant.

These results indicate that the improvements in retirement adequacy come at the cost of increased sequencing risk borne by workers. Asset allocation therefore becomes of even greater importance to workers' retirement portfolios. Workers who contribute 12% invest significantly more over the accumulation phase and any incremental gains made to the portfolio may evaporate during the critical last decade before retirement. Since the returns on a retirement portfolio dwarf the value of additional contributions made by workers close to retirement, altering the allocation of assets that govern those returns has a greater chance of achieving retirement adequacy than simply increasing contributions.

Changing the Asset Allocation

Exhibit 8 shows that different asset allocations can produce wildly different median retirement outcomes. The asset allocation of the default option has a substantial impact on retirement adequacy in regards to median outcomes. Asset allocations with a higher proportion of growth assets result in higher adequacy measures on average.

Like an increase in the contribution rate, median retirement outcomes improve where workers' retirement portfolios are comprised of a higher proportion of stocks. This suggests that TRFs tilted toward stocks may lead to more adequate retirement outcomes. The TDF strategy results in a similar median retirement outcome to the balanced TRF, indicating that a deterministic glidepath does not materially improve retirement outcomes.

The DLC strategy, however, is more successful. Apart from the strategy of a 100% stock holding, the DLC strategy produces the highest median adequacy measures, with a median RWR and RR of 15.26 times and 97%, respectively, indicating that a higher allocation to stocks combined with dynamic switching rules offers a significant improvement. The distributional statistics of the RWR retirement outcomes are presented in Exhibit 9 for the seven asset allocations.

The boxplot in Exhibit 10 shows that the TDF strategy has a very similar RWR distribution to the balanced TRF. This supports the conclusion that deterministic switching rules on their own fail to improve retirement adequacy metrics. Besides the 100% stocks strategy, the DLC strategy has the highest maximum, 75th percentile, median, and 25th percentile outcomes. The minimum outcomes for the 100% stocks and the DLC strategy are the lowest of the seven strategies, except for the 100% cash strategy, but the difference between minimums when compared to more conservative strategies appears negligible. The minimum outcomes are so far below the adequacy guideline of a RWR of 10 that this small improvement from implementing a more defensive strategy does not appear to be worth the limited upside.

We further found that TRFs tilted toward growth assets naturally achieve better retirement outcomes. But the higher allocation of growth assets also exposes the plan member to greater volatility. Exhibit 11 shows that the standard deviation is higher for strategies with a higher growth asset allocation, but this is contrasted with the LPM metrics that appropriately account for downside risk. There is a clear inverse relationship between the LPM results and the allocation to growth assets. The terminal wealth outcomes for the balanced TRF and the TDF asset allocation are not substantially different.

Exhibit 8
Median Adequacy Measures—Changing the Asset Allocation

Asset Allocation	Median RWR	Median RR
100% Cash	3.59	23%
Moderate	9.41	60%
DOA	10.78	68%
Balanced	12.32	78%
100% Stocks	18.71	119%
TDF	12.55	80%
DLC	15.26	97%

Note: Median RWR and RR results for each asset allocation under a 9% SG provision using a stationary bootstrap simulation.

EXHIBIT 9

Distribution Statistics—Changing the Asset Allocation

Asset Allocation Strategy	Min	Median	Mean	P25	P75	Max	IQRR
100% Cash	2.12	3.59	4.14	2.99	4.73	20.42	0.48
Moderate	3.14	9.41	11.02	7.33	12.88	70.81	0.59
DOA	2.98	10.79	12.67	8.24	15.06	94.89	0.63
Balanced	2.81	12.32	14.60	9.19	17.50	126.52	0.67
100% Stocks	2.29	18.71	23.29	12.48	28.65	291.74	0.86
TDF	2.84	12.55	15.00	9.34	17.91	126.06	0.68
DLC	2.29	15.26	18.69	10.78	22.63	182.81	0.78

Note: Distribution statistics for each asset allocation strategy in RWR units using a stationary bootstrap simulation.

EXHIBIT 10

Comparative Box-and-Whisker Plots for Each of the Seven Asset Allocations Using a Stationary Bootstrap Simulation. RWR Scale Set to a Maximum of 30

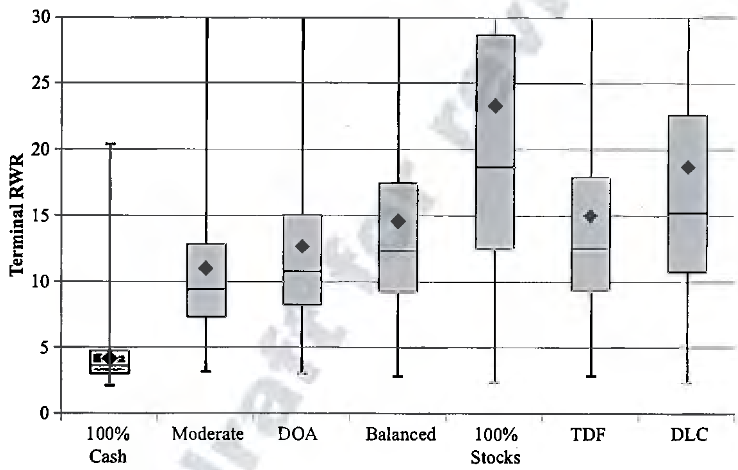


EXHIBIT 11

Investigating Sequencing Risk—Changing the Asset Allocation of TRFs

Asset Allocation	σ (*RWR*)	LPM_{FS}	LPM_{MS}	LPM_{SV}	Sortino Ratio	UPR
100% Cash	1.75	0.9300	2.9423	10.3964	–0.87	0.04
Moderate	5.60	0.1962	0.1795	0.2580	8.01	8.36
Default Option Average	6.77	0.1165	0.1090	0.1605	14.27	14.54
Balanced	8.32	0.0792	0.0779	0.1219	21.92	22.14
100% Stocks	16.94	0.0400	0.0493	0.0992	51.86	52.02
TDF	8.73	0.0726	0.0691	0.1066	24.65	24.86
DLC	12.21	0.0338	0.0418	0.0865	39.92	40.06

Note: Path volatility measures for the accumulation paths under each of the seven asset allocations (TRF, TDF, and DLC) using a stationary bootstrap simulation. Each LPM is a measure of downside risk relative to a RWR_{target} *of 6.95.* LPM_{FS} *represents the probability of falling short of the retirement target,* LPM_{MS} *represents the expected shortfall below this target, and* LPM_{SV} *represents the below target semi-variance. The Sortino ratio and the UPR evaluate the performance of each TRF relative to an* RWR_{target} *of 6.95.*

Both asset allocations have similar accumulation paths for the first 20 years of the investment horizon, where contributions are still a major part of the total portfolio. Although the TDF begins to switch toward defensive assets after this point, it is not until age 55 that the balanced TRF and the TDF hold the exact same proportion of growth and defensive assets. This is also the point where the portfolio size effect means that contributions are accounting for about one-fifth of the total portfolio value.

However, the higher returns associated with growth assets mean that the returns are compounding faster using a DLC asset allocation strategy. While the higher proportion of growth assets results in improved performance for the DLC strategy, dynamic switching rules also play their part. Exhibit 11 shows that the DLC strategy experiences a higher standard deviation but that LPM measures are substantially better. The shortfall probability (LPM_{FS}) is less than 4% for the DLC strategy, which is the lowest shortfall probability of all seven asset allocations. The DLC strategy also has the lowest magnitude of shortfall and below-target semi-variance of all seven asset allocations and is superior to the balanced TRF when comparing the Sortino ratio and *UPR*.

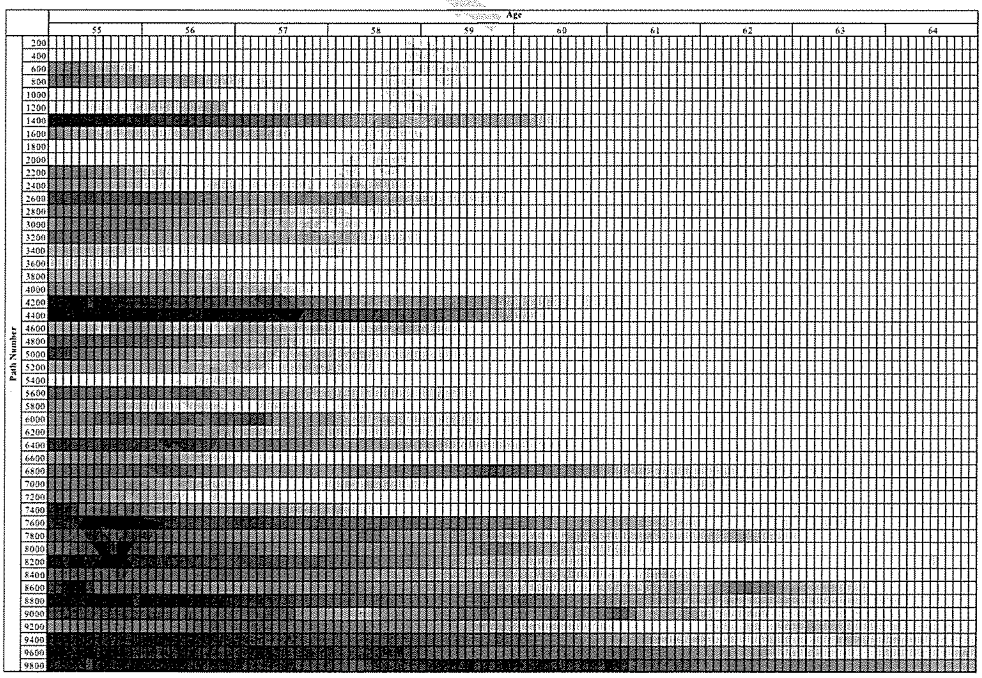
DISCUSSION

Heat Maps of the Retirement Risk Zone

We examine the simulation results in the final decade of the accumulation phase using heat maps. For ease of interpretation, we use granular shading to examine the monthly RWR relative to the adequacy target RWR_{target} of 6.95 and display the RWR sequence for every 200th path, ordered best to worst. Darker squares represent those RWRs that are closest to the minimum RWR; grey squares are closest to the 50th percentile RWR; and light squares indicate that the

EXHIBIT 12

Balanced TRF Heat Map in the Retirement Risk Zone Using a Stationary Bootstrap Simulation. Each Row Represents an RWR Sequence for Every 200th Path, Ordered Best to Worst, for the Balanced TRF Strategy in the Last Decade Before Retirement



RWR has achieved RWR_{target} of 6.95. Exhibit 12 depicts the heat map for the balanced TRF (70/30), Exhibit 13 depicts the heat map for the TDF, and Exhibit 14 depicts the heat map for the DLC strategy.

The diagrams show how each asset allocation strategy pilots the superannuation portfolio toward the retirement date. The retirement risk zone (RRZ) represents the decade immediately prior to retirement. In the RRZ, returns account for about 80% of the portfolio value. Exhibit 12 shows that the balanced TRF strategy achieves the adequacy target in only three out of 49 paths prior to the RRZ. But overall, the majority of paths eventually achieve adequacy at retirement.

Despite it taking longer for some paths to achieve adequacy, the TDF strategy in Exhibit 13 demonstrates similar adequacy outcomes. The TDF strategy has eight paths that have achieved adequacy upon entering the RRZ. However, there seems to be a larger proportion of paths below the adequacy target during the initial months. A common attribute of both the balanced TRF and the TDF strategies is that the retirement savings plans suddenly achieve (or fall behind) the adequacy target. It is not uncommon for a grey cell to turn into a white cell (or vice versa) within a single month.

The transition from inadequate savings to adequate savings is much smoother under the DLC strategy, as shown in Exhibit 14. Unlike the balanced TRF and TDF strategies, the results show that it is very unlikely that a path will fall behind the adequacy target once it has been achieved. Moreover, a higher proportion of paths are already above the adequacy target upon entering the RRZ, attributable to the higher allocation to stocks in the earlier years of the accumulation phase. Exhibit 14 also shows that the dynamic switching rules assist several paths in achieving the adequacy during the critical RRZ.

Scenario Analysis–Left Tail Outcomes

The 95th-percentile value at risk (VaR) and expected tail loss (ETL) retirement outcomes for each

EXHIBIT 13

TDF Heat Map in the Retirement Risk Zone Using a Stationary Bootstrap Simulation. Each Row Represents an RWR Sequence for Every 200th Path, Ordered Best to Worst, for the TDF Strategy in the Last Decade Before Retirement

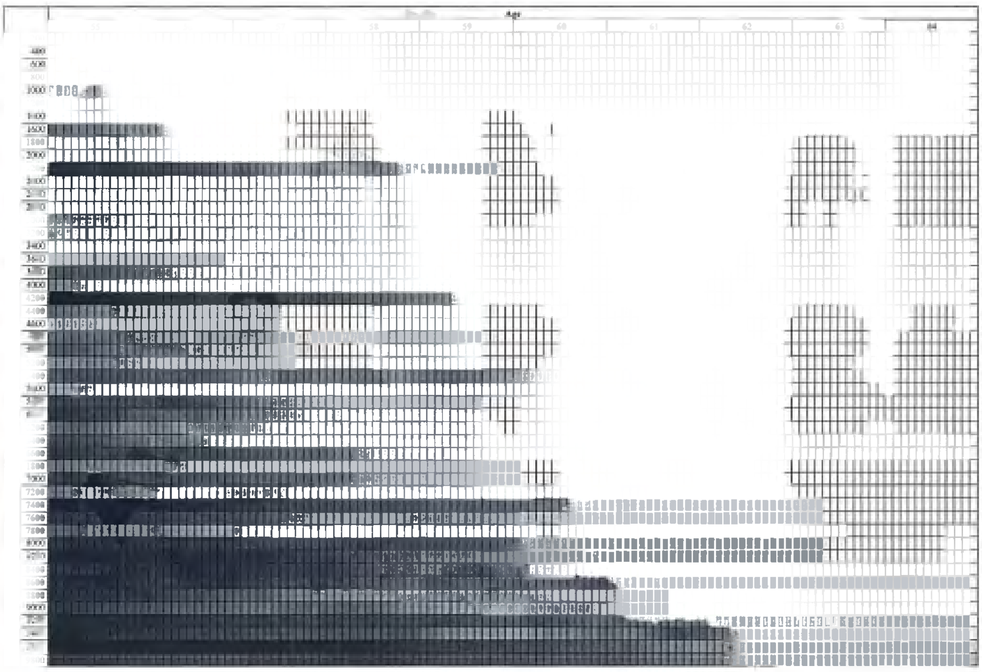
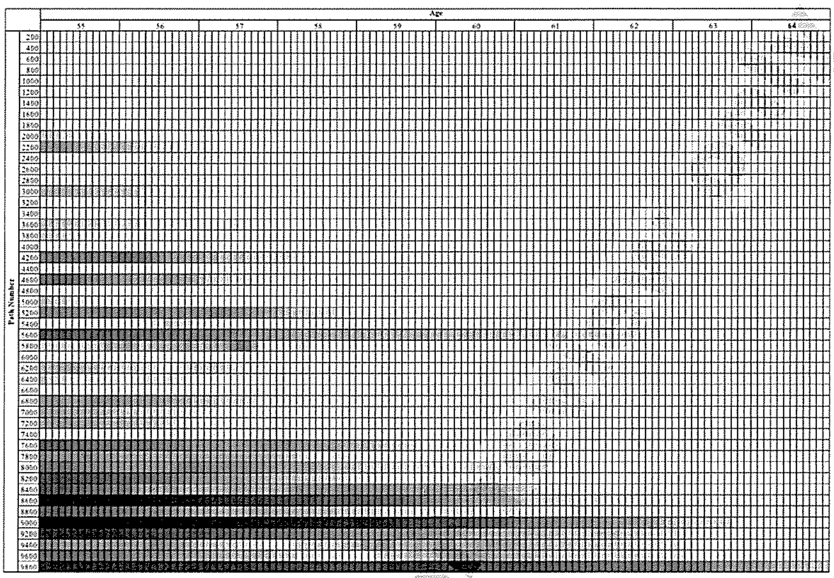


Exhibit 14

DLC Heat Map in the Retirement Risk Zone Using a Stationary Bootstrap Simulation. Each Row Represents an RWR Sequence for Every 200th Path, Ordered Best to Worst, for the DLC Strategy in the Last Decade Before Retirement



asset allocation strategy under the 9% and 12% SG provision are given in Exhibit 15. As expected, increasing the SG provision produces a commensurate increase in the tail-related risk measures for each asset allocation strategy. But both the VaR and ETL measures are higher for equity-driven strategies, including the 100% stocks TRF and the DLC strategy. This result challenges the traditional notion that stocks may adversely affect outcomes because of the higher volatility. An equity-driven strategy may actually reduce the risk of workers experiencing a poorer retirement outcome.

The VaR measures for the 9% and 12% SG contribution rate highlight the importance of the asset allocation strategy used in the default option. For instance, the VaR for a 9% SG contribution using a DLC strategy is similar to the VaR for 12% SG contribution rate using a TRF strategy. Increasing the SG provision may not be of much benefit to some workers if the asset allocation strategy chosen by the default option is inefficient.

To highlight this effect we examine two scenarios that both experience an unfortunate sequence of returns over the investment period. Scenario 1 uses a DLC asset allocation strategy with a 9% SG contribution rate. Scenario 2 uses a TRF asset allocation strategy with a 12% SG contribution rate. These are retirement outcomes on the left tails of the two RWR distributions. Exhibit 16 presents the accumulation paths.

Exhibit 15

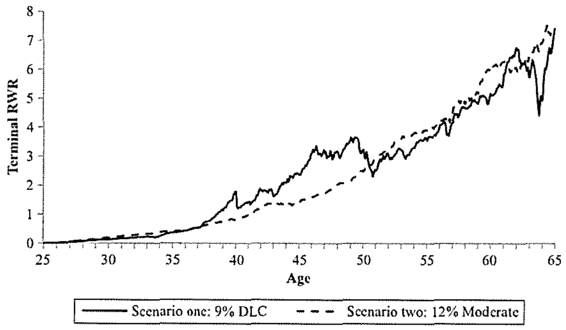
Tail-Related Risk Measures—Scenario Analysis

Asset Allocation Strategy	95% VaR (RWR)	ETL (RWR)
9% Contribution Rate		
100% Cash	2.51	2.40
Moderate	5.61	5.07
Default Option Average	6.02	5.35
Balanced	6.35	5.56
100% Stocks	7.29	6.00
Lifecycle	6.52	5.66
Dynamic Lifecycle	7.31	6.18
12% Contribution Rate		
100% Cash	3.38	3.22
Moderate	7.46	6.71
Default Option Average	7.96	7.05
Balanced	8.43	7.29
100% Stocks	9.55	7.73
Lifecycle	8.57	7.43
Dynamic Lifecycle	9.63	7.98

Note: Tail-related risk measures using a stationary bootstrap simulation.

Exhibit 16

Accumulation Paths for a 9% SG DLC Strategy and 12% SG TRF Moderate Strategy



Both scenarios experience similar retirement outcomes. The additional contributions made in Scenario 2 do not create more wealth for retirement compared to Scenario 1. The moderate TRF coasts toward the retirement outcome without any consideration of a retirement target of 9.27 times final salary. This results in a substantial shortfall. In two instances, the dynamic switching rules of the DLC strategy assisted in its pursuit of its lower retirement target of 6.95 times by maintaining or increasing the exposure to growth assets. The first occurs directly after the worker turns 55 years of age and the second occurs after a market downturn shortly before retirement. Recall that the appropriate retirement target is lower for a 9% SG provision than in a 12% SG provision because less contributions are invested, resulting a lower expected target.

The worker is thus able to achieve the appropriate retirement target associated with a 9% contribution rate. While the use of only two sample paths in this example does not prove our hypothesis, it does demonstrate how a dynamic strategy successfully aims for a target wealth outcome, while more static strategies may comply with their asset allocation objectives yet underperform intended wealth outcomes. The results demonstrate that generating adequate income for workers in retirement should be the key motivation behind designing retirement savings solutions, instead of using simple performance targets pegged to annual returns and portfolio standard deviation.

An appropriate measure for evaluating investment outcomes with multiple cash flows, such as those associated with defined contribution plans (DC plans), is the dollar-weighted return or internal rate of return (IRR) (Dichev and Yu [2011]). Exhibit 17 presents the IRR outputs from the above scenario analysis alongside the geometric return and average return for comparison. Being time-weighted, both the geometric return and the arithmetic average return are inappropriate for evaluating terminal wealth outcomes in the presence of cash flows such as contributions, because they overstate the return associated with each accumulation path. The sequence of returns experienced by the worker in Scenario 1 is worse relative to the sequence experienced under Scenario 2 because the difference between the IRR and geometric return is larger.

Exhibit 17 shows that both scenarios accumulate similar levels of wealth during the worker's life and both produce the same terminal RWR. But the IRR for Scenario 1 is significantly higher than Scenario 2. Scenario 1 outperforms Scenario 2 for workers who experience unfavorable market conditions during the accumulation phase, but at a higher risk as measured by the standard deviation. Standard deviation (as a variability metric) is a poor measure of retirement risk; the worker in Scenario 2 has contributed an additional $160,000 to simply experience a smoother accumulation path. Simply investing a greater amount to fund retirement is a poor substitute for the optimal allocation of assets through workers' lives.

Exhibit 17

9% DLC and 12% Moderate—Measures of Interest

Scenario	IRR	Geometric Return	Average Return	Total Contributions	RWR	TW	σ
(1) 9% DLC	7.50%	8.45%	9.26%	$487,559	7.41	$2,007,839	12.05%
(2) 12% Moderate	6.19%	6.70%	6.97%	$650,079	7.41	$2,006,480	7.23%

Note: Total contributions, terminal RWR, terminal wealth, IRR, and standard deviation of returns (annualized) for sample paths of the 9% SG DLC strategy and the 12% SG TRF moderate strategy.

CONCLUDING REMARKS

Using a simulation methodology, we find that the impact of increasing the SG from 9% to 12% for defined contribution plans is to increase retirement adequacy in expectation only. A large proportion of modeled retirement outcomes exceed the retirement adequacy threshold. Increasing the mandatory contribution rate has a positive impact on the retirement adequacy of workers. But retirement outcomes from increased contributions observed in the left tail of the distribution make no substantial difference in absolute terms. We consider the full distribution of potential retirement outcomes rather than central measures only.

Increasing the SG provision is therefore not a straightforward solution to improving retirement adequacy. An increase in contributions translates into workers being exposed to greater sequencing risk as the size of their superannuation portfolio grows, particularly when coupled with a static asset allocation strategy. Indeed the downside risk relative to a target appropriate for the level of contributions nearly doubles.

Using a stationary bootstrap simulation method, we find that the impact of changes in the portfolio asset allocation on retirement adequacy depends largely on the proportion of growth assets in the portfolio. TRFs with a higher proportion of stocks produce significantly better retirement outcomes and also experience less retirement inadequacy exposures despite the higher risk associated with stocks.

Target date funds (TDF) and dynamic lifecycle (DLC) strategies that change the proportion of growth and defensive assets during the investment horizon also support this result. A TDF strategy with exposure to stocks in a similar proportion to the balanced TRF produces similar retirement outcomes. The DLC strategy with a higher proportion of stocks produced substantially better retirement outcomes than the balanced TRF, mainly due to the capacity to dynamically switch allocations during the accumulation phase.

We also showed that the downside risk relative to an adequacy target was lower for the DLC strategy than for any other strategy. We showed that increasing the contribution rate for a portfolio with a static asset allocation strategy merely generates a smoother profile toward an adequacy target. The same result may be achieved at a lower contribution rate coupled with a dynamic strategy that accounts for sequencing risk exposure during the accumulation phase.

We acknowledge that there are several limitations to this study. First, retirement adequacy can be partially or fully met by the age pension and voluntary superannuation savings. Our analysis is confined to retirement adequacy under the SG regime only. Second, workers' retirement wealth ratio (RWR) may be different from those computed here due to wealth external to retirement portfolios. Third, we assumed a constant investment horizon of 40 years; clearly a different investment horizon may yield different outcomes. With a shorter investment horizon, a different default investment option than the ones we considered might be more effective in meeting retirement adequacy. Finally, in this analysis we abstracted from taxes and inflation, both of which are important factors affecting retirement adequacy.

It is worth highlighting that no investment technique can make up for a fundamentally low rate of retirement savings. The DLC approach does not enable financial advisers to pull rabbits out of hats. The DLC approach is merely an empirically-grounded strategy that can reasonably be expected to outperform the TDF and TRF strategies that are commonly used by funds.

There is scope for further research on variations of this DLC strategy. Further refinements, including more flexible switching rules, could make the strategy more applicable for retirement savings in practice. More sophisticated dynamic strategy algorithms are also an obvious area for future research.

Appendix

Exhibit A1
Superannuation Guarantee Increase Timeline

Year	Rate
2012–13	9.00%
Current rate	9.25%
2014–15	9.50%
2015–16	10.00%
2016–17	10.50%
2017–18	11.00%
2018–19	11.50%
2019–20	12.00%

Note: SG increases from 9% to 12% in seven annual steps. Note the Australian Government introduced draft legislation to delay increasing compulsory super for two years in 2013. If the legislation is passed, the next increase to a 9.5% SG will not be until 2016–2017 (Australian Taxation Office, 2013).

EXHIBIT A2
Extended Summary Statistics—Monte Carlo Simulation

Asset Allocation Strategy	Min	P25	Median	Mean	P75	Max	IQRR	Std Dev
9% Contribution Rate								
100% Cash	3.22	3.70	3.79	3.80	3.89	4.37	0.05	0.14
Moderate	3.47	7.96	9.78	10.36	12.13	31.78	0.43	3.38
DOA	3.34	8.78	11.13	11.92	14.18	47.78	0.49	4.41
Balanced	3.30	9.71	12.72	13.86	16.66	69.01	0.55	5.82
100% Stocks	2.77	12.79	18.47	21.95	27.03	166.75	0.77	13.64
TDF	3.21	9.88	13.02	14.19	17.05	72.57	0.55	6.09
DLC	2.85	11.57	16.24	19.00	23.21	143.25	0.72	10.94
12% Contribution Rate								
100% Cash	4.43	4.93	5.06	5.06	5.19	5.86	0.05	0.19
Moderate	3.98	10.59	13.02	13.77	16.15	52.78	0.43	4.49
DOA	4.60	11.77	14.92	15.98	18.87	75.19	0.48	6.00
Balanced	3.87	12.89	16.81	18.38	22.20	91.32	0.55	7.82
100% Stocks	3.45	17.02	24.69	29.59	36.26	325.87	0.78	19.10
TDF	4.29	13.06	17.26	18.80	22.65	88.89	0.56	8.07
DLC	2.98	15.55	21.84	25.08	30.62	191.45	0.69	13.93

Note: Extended summary statistics of Monte Carlo simulation of RWR distributions for seven asset allocation strategies.

EXHIBIT A3
Extended Summary Statistics—Standard Bootstrap Simulation

Asset Allocation Strategy	Min	P25	Median	Mean	P75	Max	IQRR	Std Dev
9% Contribution Rate								
100% Cash	3.20	3.70	3.79	3.80	3.89	4.51	0.05	0.15
Moderate	3.37	7.93	9.80	10.35	12.16	39.58	0.43	3.43
DOA	3.36	8.78	11.12	11.90	14.13	55.26	0.48	4.44
Balanced	3.04	9.65	12.58	13.72	16.51	77.30	0.55	5.86
100% Stocks	2.31	12.69	18.48	21.94	27.06	222.33	0.78	14.21
TDF	2.91	9.79	12.82	14.09	16.96	81.09	0.56	6.19
DLC	2.31	10.92	15.35	17.67	21.50	127.42	0.69	9.94
12% Contribution Rate								
100% Cash	4.38	4.94	5.05	5.06	5.18	5.86	0.05	0.19
Moderate	4.52	10.67	13.09	13.88	16.28	52.74	0.43	4.56
DOA	4.41	11.83	14.87	15.95	18.98	69.53	0.48	5.90
Balanced	4.21	13.01	16.83	18.40	22.11	91.41	0.54	7.74
100% Stocks	3.35	17.16	24.72	29.43	36.38	232.79	0.78	18.58
TDF	4.55	13.23	17.15	18.88	22.64	88.85	0.55	8.13
DLC	3.35	14.80	20.44	23.66	28.80	143.03	0.68	13.02

Note: Extended summary statistics of Efron (1979) bootstrap simulation of RWR distributions for seven asset allocation strategies.

Exhibit A4

Extended Summary Statistics—Stationary Bootstrap Simulation

Asset Allocation Strategy	Min	P25	Median	Mean	P75	Max	IQRR	Std Dev
9% Contribution Rate								
100% Cash	2.12	2.99	3.59	4.14	4.73	20.42	0.48	1.75
Moderate	3.14	7.33	9.41	11.02	12.88	70.81	0.59	5.60
Default Option Average	2.98	8.24	10.79	12.67	15.06	94.89	0.63	6.77
Balanced	2.81	9.19	12.32	14.60	17.50	126.52	0.67	8.32
100% Stocks	2.29	12.48	18.71	23.29	28.65	291.74	0.86	16.94
TDF	2.84	9.34	12.55	15.00	17.91	126.06	0.68	8.73
DLC	2.29	10.78	15.26	18.69	22.63	182.81	0.78	12.21
12% Contribution Rate								
100% Cash	2.82	4.03	4.79	5.53	6.26	45.22	0.47	2.37
Moderate	4.20	9.81	12.49	14.65	17.05	136.09	0.58	7.68
DOA	3.90	10.97	14.37	16.80	19.67	146.65	0.61	9.15
Balanced	3.60	12.14	16.47	19.32	22.94	156.68	0.66	11.10
100% Stocks	2.82	16.42	24.77	30.56	37.57	333.13	0.85	21.97
TDF	3.74	12.38	16.78	19.84	23.63	171.56	0.67	11.65
DLC	2.28	14.18	20.43	24.66	29.84	252.16	0.77	16.14

Note: Extended summary statistics of stationary bootstrap simulation of RWR distributions for seven asset allocation strategies.

ENDNOTE

This research was supported by the CSIRO-Monash Superannuation Research Cluster, a collaboration among CSIRO, Monash University, Griffith University, the University of Western Australia, the University of Warwick, and stakeholders of the retirement system in the interest of better outcomes for all. We are also grateful for valuable input from Sandy Mackenzie.

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Withdrawal Capacity in the Face of Expected and Unexpected Health and Aged-Care Expenses During Retirement

MICHAEL E. DREW, ADAM N. WALK, AND JASON M. WEST

MICHAEL E. DREW
is a professor in the Department of Accounting, Finance and Economics at Griffith University in Queensland, Australia.
michael.drew@griffith.edu.au

ADAM N. WALK
is a research fellow in the Department of Accounting, Finance and Economics at Griffith University in Queensland, Australia.
a.walk@griffith.edu.au

JASON M. WEST
is an associate professor in the Bond Business School at Bond University in Queensland, Australia.
jwest@bond.edu.au

Fundamentally, the economic well-being of individuals is largely determined by their command over economic resources, including the income and wealth that is available to support their consumption of goods and services. This includes the funding of retirement. Individual retirement planning is a critical practice observed in most modern societies as the fiscal burden on the State to fund retirees is increasingly placed under pressure. Saving, wealth management, and prudent planning have allowed individuals to increasingly finance at least part of their retirement, with a decreasing reliance on the State. Many older people also own their homes and have accumulated other assets that can be used in retirement to support living standards. It is natural for the cost burden of age-related health treatment and aged-care services to also eventually shift to individuals. However, individual wealth planning and the impact on income sustainability and stability in reaction to this shift in liability have escaped systematic analysis.

It is well-documented that the profile of the population is aging within most developed countries. Aging naturally affects individuals across a number of domains, including physical and mental health, housing, income security, opportunities for social and economic participation (including labor force participation), and wealth-management priorities. The decline in defined benefit (DB) pension plans and the transition to defined contribution (DC) plans is gradually expanding liability management from specifically funding retirement income to the financing of a wider range of social responsibilities, including age-related health treatment, appropriate housing, and aged-care management services and facilities. Australia provides a topical case study of these issues, given the dominance of DC (or superannuation) plans.

Typical individual lifecycles comprise a period of employment followed by a period of retirement. Increasingly it falls to individuals to reallocate consumption from their working life to retirement if they wish to enjoy financial security and avoid poverty in old age. DC pension plans can achieve this reallocation in a way that is consistent with the preferences of the individual plan member.

To achieve this, there are generally three key preferences that individuals take into account. First, preference is favored toward an ability to smooth consumption across different possible states of nature within any given time period (asset diversification). Second, preference appears to be simultaneously awarded to the ability to smooth consumption across different time periods (temporal diversification). Third, the tension between current versus future consumption necessarily means that saving for retirement and other costs involves the sacrifice of certain consumption today in exchange for uncertain consumption in the future. In the literature the main elements of uncertainty remain manifest in both future labor income and the returns on the assets in which the retirement savings are invested. However future liabilities for both age-related health treatment and aged-care facilities are seldom identified by retirees as forming an essential cash flow need later in life (Quine and Carter [2006]). Indeed, it is arguable that investors don't tend to think of retirement consumption as a liability at all. Investors may count their superannuation portfolio as an asset, but often forget to count the liabilities for which the asset is held.

DC plan workers intuitively (rather than systematically) form a view on both the trade-off between consumption in different states of nature in the same time period, and the trade-off between consumption and consumption variability in different time periods. Of course, attitude and expectations related to these trade-offs will influence the optimal funding and investment strategies of the pension plan. Explicit consideration of potential costs incurred toward the end of one's life tends to be an unsavoury reality, and so it is largely ignored by financial advisors and retirees until an immediate need arises to meet such expenses. DB plan members obviously face the same risks, but income stability means they are at least marginally better able to systematically plan for such costs, where such planning takes place.

This study examines the impact of anticipating the costs associated with age-related health treatment and aged-care services during the retirement phase on income level, income stability, and longevity risk. To measure the impact on income sustainability and longevity, we simulate asset return data using historical bootstrap simulation to derive an optimal withdrawal income during retirement for a range of confidence levels. This allows us to test the sensitivity of income sustainability in relation to the retirement horizon, the magnitude and timing of health and aged-care costs, unexpected longevity, and the interplay between risk aversion and asset allocation during retirement. Given the myriad potential health and aged-care expenses that retirees may face, we impose a constraint on expenses to derive a series of baseline ruin probability profiles that quantify the impact of the timing and magnitude of health and aged-care costs on the safe withdrawal rate for a typical retirement portfolio.

Our analysis considers investors who either anticipate future health/aged-care costs or who fail to anticipate such future costs. The results establish a number of important findings regarding the probability of investors outliving their retirement portfolio. First, we show that the greatest risk to income sustainability occurs when unexpected health costs combine with greater longevity (without a commensurate adjustment in asset allocation toward assets with a more favorable risk-return profile). This combination risks premature wealth depletion, particularly for risk-averse investors who bias their asset allocation toward low-risk assets.

Second, we show that the safe withdrawal rate is highly sensitive to the timing of health costs and moderately sensitive to later-life aged care costs. Third, we show that in a set of broad circumstances, the risk of premature wealth depletion can be mitigated through a type of dynamic lifecycle (DLC) strategy during the retirement phase.

BACKGROUND

It is instructive to present an overview of the total number, the housing situation, and the health situation of retirees in a representative country to better understand the nature of the cost profile for later-in-life liabilities. In Australia, there are about 3.3 million people aged 65 years or older (referred to hereafter respectfully as "older people"), representing about 14% of the total population (ABS [2012]). The number of older people is expected to reach between 6.2 million and 7.9 million by 2050. This equates to around 25% of the population. It is important to note that about half of the current number of older people (7.5% of the total, or 1.7 million people) also have a disability (ABS [2012]).

According to 2012 Australian Bureau of Statistics research, more than 90% of older people live in a private dwelling (i.e. house, apartment, or home unit) and nearly three-fourths of these (71%) live with others. Among those aged 80 years or more, 77% live in a private dwelling and more than half (58%) are still living with others. In addition, 5.5% of older people are housed in cared-accommodations while 4.0% live in "other non-private dwellings," such as caravan/trailer parks or self-care units in retirement villages. These proportions of older people are likely to remain high, with Australian

Government policy regarding aged care pointing toward a greater emphasis on aging at home before advancing to residential aged care when greater medical intervention in required.

As people age, their physical and mental functioning sometimes deteriorates and they become more susceptible to age-related conditions. More than 87% of older people (but just 31% of those aged less than 65 years) report having a long-term health condition. Of older people who report a long-term health condition, 93% are most affected by a physical condition and 7% are affected by a mental or behavioral disorder. These conditions range from arthritis (16%) and hypertension (11%) to back problems (9.4%). Even though the majority of older people live with others, about 60,000 people with a profound core-activity limitation live alone. More than 29% of older people need direct assistance with certain personal activities including health care (25%), mobility (18%), property maintenance (23%), and household chores (18%) (ABS [2012]).

Certain health conditions are chronic among older people. The prevalence of arthritis increases with age, from less than 1% of those aged under 25 to 52% of people aged 75 and over. Women are considerably more likely to have arthritis than men; at ages 75 and over, about 60% of women have arthritis, compared with 42% of men. The prevalence of cancer also increases with age, with 7% of people aged 75 and over having cancer (compared with 1% of people aged 45–54). More men than women have diabetes (5% of men versus 4% of women aged 2 years and over), and, as with many health conditions, the rate of diabetes increases with age. People aged 75–84 have the highest rate of diabetes (17%). Lastly, it is well known that heart disease remains one of the leading causes of death worldwide, and the statistics in Australia largely support this observation. The proportion of people with heart disease increases steadily with age, such that more than one-fourth (29%) of people aged 75 and over have heart disease. The highest rate of heart disease (47%) is observed in men aged 85 and over.

The ABS surveys also reveal that the prevalence of some of the more costly health conditions dramatically increases with age. For example, those aged 80 or over are seven times more likely to identify dementia or Alzheimer's disease as their main long-term health condition than those aged 65 to 79 (7.6% compared with 1%). In contrast, the proportion of those who reported arthritis as their main condition was similar across these age groups (17.3% compared with 15.9%). The trend appears to be that high-cost health condition treatment and care services needed to cope with the increased life expectancy of the population will predictably have a far greater impact on retirement wealth than the lower-cost health services related to less acute age-related conditions.

In socio-demographic terms, the proportion of people with heart disease and diabetes increases as the level of disadvantage (poverty) increases. People living in areas of most disadvantage are more than twice as likely to have diabetes and heart disease than those living in areas of least disadvantage (8% compared with 3%). Over 75% of older Australians reside in a household with gross household income in the lowest two quintiles, while only 5.3% of older people are in the highest quintile. There are social implications associated with this fact that lie beyond the scope of this analysis. However, a great proportion of retirees will incur the burden of health and aged-care service costs themselves, and so planning for such liabilities is increasingly important.

Improvements in the treatment for certain illnesses, such as cancer, have accelerated in the past two decades. The survival rate for many cancers has increased by 30% over the past 20 years. For instance, in 2006 the five-year survival rate (the percentage of patients alive five years after initial diagnosis) for the most common cancer in Australian women (breast cancer) was 88%, and in 2010 the five-year survival rate for the most common cancer in Australian men (prostate cancer) was 85% (AIWH [2010]). Such statistics cause us to sharpen our focus on retirement planning: if survival probabilities are rising for even those with the direst of health conditions, then retirement planning becomes even more critical.

As people age their housing needs change; they may modify their existing home to accommodate ramps and rails, install modest low-maintenance accommodation features, or move to a smaller dwelling or an aged-cared facility (Productivity Commission [2008]). The most expensive place for older people to live is in residential aged care (Allen Consulting [2002 and 2007]). In 2012 the average annual cost to the government for a person in residential aged care was more than $40,000, compared with $3,800–$7,000 for those who stayed in their own homes (depending on the level of care needed).[1] In return for government subsidies that support homeowners, it is likely that retirees will be required to provide more for their retirement, including health care and aged care costs (Bruen [2005], Yee [2005]). A comprehensive report by Grant Thornton in 2012 concluded that high-care aged facilities cost an average of $80,000 per bed (Ansell et al. [2012]).

In 2012, a government pension or allowance was the main source of income for two million older Australians (65%). People aged 65 and over without disability were three times more likely to receive a wage or salary as their main source of income than those with a disability (10.4% compared with 3.4%).

However, fiscal constraints mean that nations (including Australia) are unlikely to be able to fully support an aging population of retirees for 20 to 40 years' worth of pension payments. It is our conjecture that while we consider the Australian setting in this study, the need for liability-driven and goals-based investing has emerged for retirees in the United States and many other countries—an effort that should be aided by prudent social policy globally. A goals-based approach focuses on funding personal financial goals and requirements rather than simply achieving higher investment returns relative to the market. Further, such an investment approach focuses more on household risk capacity than on risk tolerance. This approach is broadly similar to asset-liability management approaches employed at insurance companies and liability-driven investment strategies at pension funds. It is distinguished from these, however, in that it integrates financial planning and investment management to ensure that household goals (including health and aged-care services costs) are financed efficiently (Fizel and Nunnikhoven [1992]).

For a goals-based investing approach to be most efficient, it must consider all household assets and liabilities across a lifetime. Assets represent the full set of resources available to the investor, such as financial assets, real estate, employment income, and social security. Liabilities represent all financial liabilities, such as loans and mortgages, in addition to the capitalized value of the household's financial goals and aspirations.

For this approach to be successful, the required and/or desired income level in retirement needs to be articulated from the outset. The ultimate aim of this approach is therefore to guard against poor investment decisions by providing a clear process for identifying goals and choosing investment strategies for those goals. This approach adapts investment style to actual investors, and also makes it unnecessary for investors to have a superior understanding of financial markets and investment strategies.

METHODOLOGY

The success of a retirement portfolio in the presence of asset price volatility and liability uncertainty is a complicated problem in which the objective function cannot be evaluated precisely. When confronted with such issues, historical bootstrap simulation is widely accepted as a means of estimating the objective function by randomly generating values for uncertain outcomes from a known distribution of input variables.

Model Worker

We illustrate the impact of later-in-life health and aged-care costs using the simple case of a typical female employee aged 50 who has made contributions to her pension plan throughout her working life, amounting to a modest $250,000 in superannuation.[2] She faces asset-return risk both during the accumulation phase and the retirement phase. This affects the value of her superannuation fund, given past and future contributions. We have specifically chosen a female investor to underline a key problem in retirement planning for many individuals: relatively low wealth coupled with a longer life expectancy.

We examine two aspects of her capacity to cover health costs and aged-care costs: anticipated or expected cost occurrence, and unanticipated or unexpected cost occurrence. We have chosen to work with annual returns in real terms.

We chose the high-care level of health/aged-care costs of $80,000 to represent the potential of a significant health issue to affect the investor, from which portfolio recovery will be highly dependent on risk appetite. This level represents a cost impost of around 12% of her median portfolio value at the date of retirement.

Constant Inflation Adjusted Withdrawals—Stochastic Optimization

The model assumes that the retiree begins retirement with an initial withdrawal from her retirement portfolio and invests the post-withdrawal portfolio remainder in stocks, bonds, and cash. The portfolio earns an inflation-adjusted rate of return, weighted initially by a constant asset allocation, until the next annual withdrawal. A discrete time representation of the portfolio rate of return is

$$r_t^i = \sum_{j=1}^{n} w_{t,j} r_{t,j}^i, \tag{1}$$

where r_t^i is the weighted average portfolio return for simulation i at time t, $w_{t,j}$ is the portfolio proportion assigned to asset class j at time t, and $r_{t,j}^i$ is the annual inflation-adjusted return for asset j at time t for simulation i. Ongoing withdrawals from the portfolio remain the same (in inflation-adjusted dollars), and the value of the portfolio is derived as

$$V_t^i = [V_{t-1}^i - MV_0](1 + r_t^i), \tag{2}$$

where V represents the value of the portfolio and M is the constant withdrawal fraction amount.

We need to use stochastic optimization in the model to identify the optimal withdrawal rate for a set of asset allocations and a known investment horizon that minimizes the probability of portfolio ruin. We use the stochastic optimization process for three cases; optimal withdrawal rates in the absence of health and aged-care liabilities, optimal withdrawal rates in the presence of expected health and aged-care liabilities, and optimal withdrawal rates after the occurrence of unexpected health and aged-care liabilities.

Prior to retirement we incorporate annual cash flows into the accumulation account up to the nominated date of retirement as well as initial portfolio conditions. The portfolio value V_t at time t is defined as

$$V_t = (V_{t-1} + CF_{t-1})(1 + X_t) - LS_\tau + 1_E(SSP_{\tau<T}); \;\; t, \tau < T, \tag{3}$$

where CF_t is the after-tax cash inflow (positive) or outflow (negative), X_t is the weighted average portfolio return $w_n' r_n$ at time t, LS_τ is any lump sum payment withdrawn at retirement date τ, and $1_E(SSP_{t>\tau})$ is an indicator function where 1_E is equal to one if the investor qualifies for social security payments (SSP) during retirement $t>\tau$ and zero if the investor does not qualify for such payments. Both the retirement date τ and the withdrawal dates t are assumed to be less than the terminal date T for all payments as selected by the investor. The value V_t of the portfolio at $t = 0$ is set to the initial portfolio value of the investor.

In contrast with deterministic approaches to retirement planning, where both the investment horizon and the investment return are assumed to be known with certainty, in this analysis we represent the variables as stochastic. We derive the stochastic present value at either the date of retirement (which assumes a deterministic terminal portfolio value) or at any point before retirement as

$$\widehat{PV} = \sum_{i=1}^{\tilde{T}} \prod_{j=1}^{i} (1 + \tilde{r}_j)^{-1}, \tag{4}$$

where $\tilde{T}$ is the random time of death (in years) and $\tilde{r}_j$ is the random investment return in year j. As $\tilde{T} \to \infty$ the stochastic PV simply reduces to the infinitely-lived endowment (Milevsky [2006]). The frequency of the above measure can be reduced to quarters or months as required without loss of generality.

The simulation process in this model assumes $\tilde{T}$ is fixed and is estimated by the investor. This greatly simplifies the simulation and the optimization process. For the purposes of illustrating the model process, the age of death is assumed to be 80, 90, or 100. The relatively small chance of living to 100 means that most individuals who assume their expiry date of 100 may in fact overstate the probability of ruin.

The asset values and projections are simulated 10,000 times and the key percentiles at each time t are estimated from the simulation. A range of percentiles is extracted from the simulated terminal values (at time T) for the investor's portfolio and then used as the future value to iterate backwards to retirement date τ. To conduct the search we use a simple generalized reduced gradient search algorithm (Lasdon et al. [1978]) to solve for the annual withdrawal over the withdrawal period ($\tau \to T$), which is also simulated 10,000 times to achieve convergence. This method is sufficiently robust to find at least a local optimum where the function is continuously differentiable. This approach is also known to be robust relative to other nonlinear optimization methods.[3]

The investor has the choice to alter the risk of the portfolio (through asset allocation). For this model we assume three asset classes (stocks, bonds, and cash) and across five broad sets of asset allocations that represent relative levels of risk aversion. The weightings for each category are provided in Exhibit 1.

EXHIBIT 1

Asset Class Weights for 10 Levels of Risk Aversion

Risk	Stocks	Bonds	Cash
Very high	90%	10%	0%
Moderate	50%	40%	10%
Balanced	40%	40%	20%
Conservative	30%	40%	30%
Very low	10%	30%	60%

A simulation of 10,000 iterations generates a single probability of ruin for a given portfolio allocation, age at retirement, stochastic inflation-adjusted portfolio return, deterministic occurrence of death, and a fixed stochastically-optimized withdrawal rate. Each set of simulations is conducted to derive the impact on withdrawal rates and the probability of ruin for the three cases:

1. optimal withdrawal rates in the absence of health and aged-care liabilities,
2. optimal withdrawal rates in the presence of expected health and aged-care liabilities, and
3. optimal withdrawal rates after the occurrence of unexpected health and aged-care liabilities.

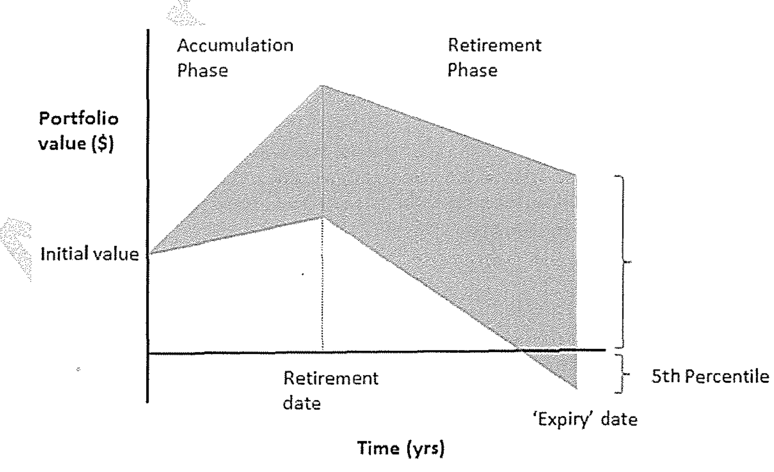
To solve for the optimal withdrawal rate we use the complex method of constrained optimization first proposed by Box [1965] and then improved by Guin [1968]. This approach is capable of optimizing a complex objective function with few constraints on the optimization function itself while also avoiding the need to explicitly compute the derivatives of the function itself. Studies by Stout and Mitchell [2006] and Stout [2008] have used a similar algorithm to identify optimal withdrawals for a narrower suite of input parameters. From the results we will be able to better understand both the optimal investment strategy and the optimal withdrawal rate when significant health and aged-care liabilities are taken into consideration.

This optimization methodology can be more simply demonstrated using a diagram. Exhibit 2 shows that the simulation estimates the range of outcomes available to an investor through both the accumulation and retirement phases. The stochastic optimization process aims to select a constant withdrawal rate through the retirement phase that yields an expected terminal wealth of zero at the 5% confidence level coinciding with the investor's "expiry" date (death or other nominated future date). The Box Method iteratively searches possible input values for withdrawal amounts to reduce the simulated probability of ruin at a 5% confidence level, to find a global minimum solution (if one exists). The optimal withdrawal values are then used in a second set of block bootstrap simulations to estimate the probability of portfolio ruin.

Ultimately the model is able to answer the basic question: At what level can investors set their retirement

EXHIBIT 2

Simulation Process for Investor Estimating a Fixed Withdrawal Rate Leading to Terminal Wealth Depleting to Zero at the Fifth Percentile



income expectations and expenditure levels? This motivates investors to focus on the almost certain income level which we set to a confidence level of 5%, and avoids setting the objective function to simply maximize wealth at the date of retirement and then hope the portfolio value is sufficient so that they do not outlast their portfolios. Indeed, the intention of goals-based investing is to match the time-weighted value of assets and liabilities that cater for cash flows through an investor's working life as well as through retirement.

DATA AND CALIBRATION

Asset class return data for the historical bootstrap model were obtained from Global Financial Data (GFD). The S&P/ASX 200 Accumulation Index (in AUD) return series is used to represent Australian stocks. This index uses Lamberton's indexes for the Australian Stock market from 1882 to 1958, Sydney's All-Share indexes from 1958 to 1971, the Statex Accumulation Index from 1971 to 1979, the ASX All-Ordinaries Index from 1979 to May 1992, and the S&P/ASX 200 Accumulation Index from June 1992 to December 2013. Prior to 1971, the total return was calculated based upon price indexes and dividend yield data for the Australian Stock Exchange. The 10-year Government Bond Return Index (in AUD) returns series was used to represent Australian bond data. This data were obtained from *The Economist* for 1858–1931, D. McL. Lamberton, "Security Prices and Yields, Part III," *Sydney Stock Exchange Official Gazette* (December 15, 1958, p. 556) for 1875–1925, the *League of Nations Statistical Yearbook* (Geneva: League of Nations) for 1926–1945, the *New South Wales Statistical Register* for 1946–1956 and the Reserve Bank of Australia (*Monthly Statistical Bulletin*) for 1956–2013. Total Returns Bills Index (in AUD) is used to represent Australian cash returns. The data were obtained from *The Economist* for 1858–1931, D. McL. Lamberton, "Security Prices and Yields, Part III," *Sydney Stock Exchange Official Gazette* (December 15, 1958, p. 556) for 1875–1925, the League of Nations for 1926–1945, and the Reserve Bank of Australia, *Statistical Bulletin* for 1970–2013. The bill index uses the bank deposit rate from 1834 until June 1928 and Treasury bill yields thereafter. We collated and synchronized the data to derive a series of annual returns from October 1882 to December 2013 (see Exhibit 3).

Long-term assets exhibit mean reversion, there is a positive long-run equity risk premium, most assets exhibit leptokurtosis, and the contemporaneous correlation between financial asset returns and real earnings growth is not strong. We also find evidence that the real yield on T-bills exhibits some degree of persistence over time however when we measure serial correlation at a yearly frequency most of the persistence disappears.

EXHIBIT 3
Summary Statistics for Annual Return Series (Linear) of Australian Stocks, Foreign Stocks, Australian Bonds, and Australian Bills, October 1882–December 2013

	Australian Equities	Australian Bonds	Australian Cash
Mean	12.12%	5.88%	4.20%
Stand Dev	13.03%	7.86%	1.00%
Skew	−0.24	0.17	0.51
Kurt	4.17	4.14	3.27
JB-Stat	312	278	222
P-value	0.00	0.00	0.00

RESULTS

Anticipated Health and Aged-Care Costs

The objective function of the model is to maximize the annual withdrawal of income subject to the constraint that the probability of ruin is minimized over the expected life of the investor. In the case where investors anticipate some form of cost requirement to finance health and/or aged care costs at some point during their retirement, investors will naturally ease back on their withdrawals so that there are sufficient funds in their portfolio to both pay the discrete cost and fund the remainder of their retirement. Therefore the objective function we employ here takes into consideration the need for an investor to withstand a single $80,000 discrete payment at some point during retirement.

We provide the optimal withdrawal rates computed as the fifth percentile of the median (expected) portfolio value at the date of retirement with anticipated health and/or aged-care costs of $80,000 due at any point, for three life expectancies (Exhibit 4).[4] For example, investors who are relatively healthy and expect to live to 90 years of age with retirement savings invested in a balanced portfolio, and expect to pay a liability of

EXHIBIT 4

Fifth Percentile Annual Optimal Withdrawal Rates for Each of the Five Asset Allocation Portfolios when Anticipating Health/Aged-Care Costs Assuming a Given Life Expectancy

Life Expectancy	Portfolio	Withdrawal Rate	Withdrawal $	% of Unexpected Withdrawals
80	Very high	3.83%	36,250	92.66%
	Moderate	5.16%	32,430	83.96%
	Balanced	5.05%	32,423	86.82%
	Conservative	5.00%	29,887	82.44%
	Very low	5.04%	27,501	94.36%
90	Very high	2.92%	27,639	90.71%
	Moderate	4.16%	27,501	92.63%
	Balanced	4.28%	24,751	89.56%
	Conservative	3.68%	21,015	80.12%
	Very low	3.43%	18,750	94.89%
100	Very high	2.90%	22,778	82.41%
	Moderate	3.50%	22,901	84.09%
	Balanced	3.15%	21,821	80.88%
	Conservative	3.14%	18,750	88.11%
	Very low	2.63%	14,376	86.80%

$80,000 at any point during retirement, will optimally withdraw 4.28% of their expected portfolio value at the date of retirement each year. This equates to $24,751 per year.

The fifth column provides the withdrawal value for an investor who anticipates health and/or aged-care costs of $80,000 as a percentage of the withdrawal value for an investor who does not anticipate health and/or aged-care costs. This value is always less than 100%, to allow for the increased liability of anticipated health and/or aged-care costs to those who expect it. There is some variability across investment portfolio risk profiles but generally very high and very low portfolio risk profiles result in a higher ratio.

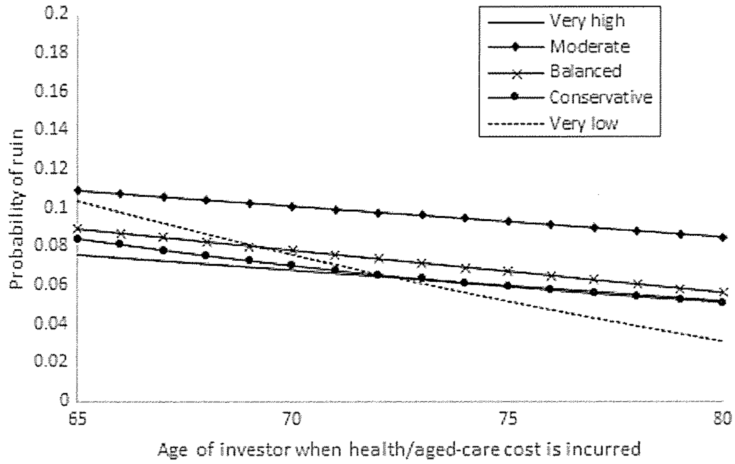
Exhibit 5 depicts the probability of ruin profiles for our investor who incurs $80,000 in health and/or aged-care costs at a given point during retirement, and lives to the age of 80. These estimates were obtained for a range of five asset allocations—very high, moderate, balanced, conservative, and very low. For instance, the probability of portfolio ruin for the investor who incurs health and aged-care costs at age 65 with a constant asset allocation to a moderate portfolio is about 7%. All of the asset allocations result in broadly similar ruin profiles for this short horizon, and the ruin probability is not very sensitive to risk preference.

Exhibits 6 and 7 depict the same optimization process and ruin profiles for an investor who looks to extend the retirement horizon to 90 years of age and 100 years of age, respectively. The probability of ruin for all asset allocations declines relative to the 80 years of age horizon because investors lower their spending rate during retirement to cover an expected health and/or aged care cost liability during retirement. Additionally, each portfolio has sufficient time to recover from a cost liability such that the probability of ruin is either stable or gradually declines.

Increasing the retirement period clearly equates to a reduction in the withdrawal rate, but reducing the probability that $80,000 in health care expenditures will be incurred in a given year also reduces the probability of ruin.[5] Exhibits 5 to 7 illustrate that the probability of ruin gradually declines when the year in which health care expenses are incurred is later in retirement for each portfolio risk profile. Note that the optimization algorithm was designed for a constant probability of ruin and a stochastic time period of incurring health care expenditures to arrive at a withdrawal rate, since few investors will know in advance when their health will deteriorate. Taking the optimized withdrawal amount for each investor type results in a higher probability of ruin if costs are incurred earlier in retirement. Exhibits 5 to 7 illustrate this outcome to highlight that the probability

Exhibit 5

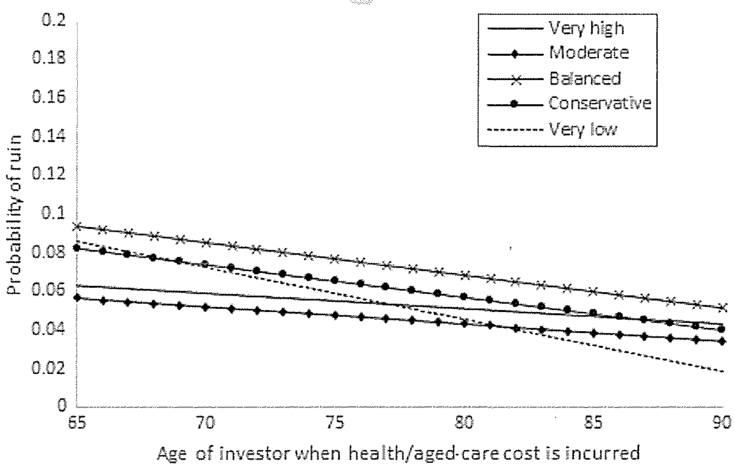
Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Known Health and Aged-Care Costs Incurred at Each Age – 80 year horizon



Investor initial age 50, retirement age 65, investment horizon age 80, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000. Optimal withdrawal rates are used.

Exhibit 6

Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Known Health and Aged-Care Costs Incurred at Each Age – 90 year horizon



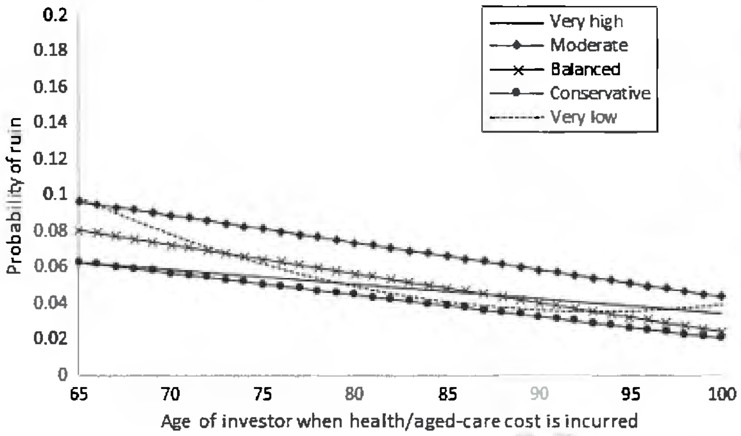
Investor initial age 50, retirement age 65, investment horizon age 90, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000. Optimal withdrawal rates are used.

of ruin is less sensitive to the timing of health care costs for those who anticipate such a liability during retirement than for those who do not. This will become clear in the next Section.

If we use the ASFA Retirement Standard Modest lifestyle for a single person of $23,363 per year expecting to live to 90 years of age, we observe the probability of ruin profiles in Exhibit 8.[6] Similarly if we use the

EXHIBIT 7

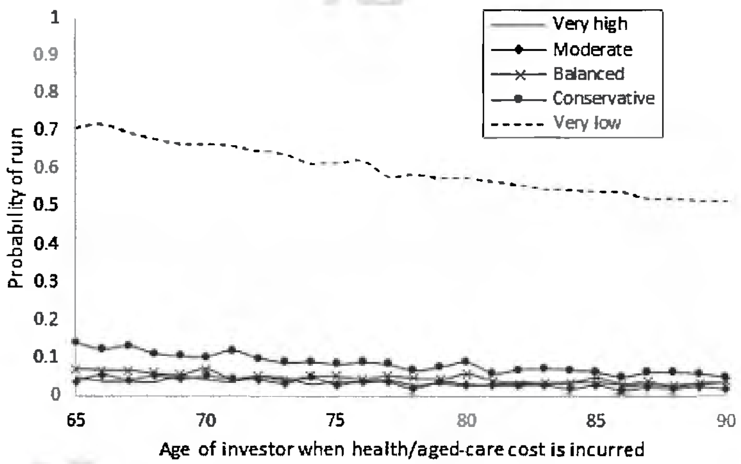
Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Known Health and Aged-Care Costs Incurred at Each Age – 100 year horizon



Investor initial age 50, retirement age 65, investment horizon age 100, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000. Optimal withdrawal rates are used.

EXHIBIT 8

Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Known Health and Aged-Care Costs Incurred at Each Age – 90 year horizon, ASFA Modest Single



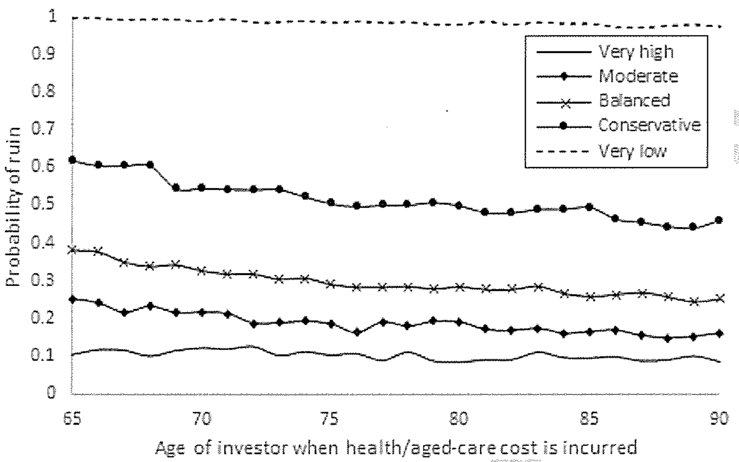
Investor initial age 50, retirement age 65, investment horizon age 90, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000. Withdrawal rate of $23,363 per year used (ASFA Retirement Standard Modest lifestyle for a single person).

ASFA Retirement Standard Modest lifestyle for a couple of $33,664 per year we observe the probability of ruin profiles in Exhibit 9.

At a marginally higher withdrawal rate, investors incurring significant health and/or aged-care costs will experience a potentially higher probability of ruin early during the retirement phase if assets are too conservatively invested. Ruin is very high for low-risk portfolios; higher-risk portfolios that are heavily weighted toward stocks exhibit a low and declining probability of ruin

EXHIBIT 9

Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Known Health and Aged-Care Costs Incurred at Each Age – 90 year horizon, ASFA Modest Couple



Investor initial age 50, retirement age 65, investment horizon age 90, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000. Withdrawal rate of $33,664 per year used (ASFA Retirement Standard Modest lifestyle for a couple).

through the retirement phase. Our findings confirm the notion that, particularly in the retirement phase, the investment decisions we make can simply result in the exchange of one kind of risk (say, ruin) for another (say, volatility). At a significantly higher withdrawal rate, however, investors incurring significant health and/or aged-care costs will experience a potentially higher probability of ruin early in the retirement phase if assets are invested in conservative portfolios. As shown in Exhibit 9, ruin is almost certain for very-low-risk portfolios, while higher-risk portfolios that are heavily weighted in stocks exhibit a declining probability of ruin through the retirement phase. Indeed, higher-risk portfolios are dominant against portfolios containing a declining risk profile.

For higher withdrawal rates, when incurring significant health and/or aged-care costs, the probability of ruin is generally directly related to the level of risk implicit in the asset allocation. As shown in Exhibit 9, ruin is almost certain for low-risk portfolios while, for higher-risk portfolios that are heavily weighted in stocks, the probability of ruin is significantly less and some degree of portfolio recovery is possible.

Unanticipated Health and Aged-care Costs

We now consider the same analysis, but for an investor who fails to anticipate any form of health or age-care costs during retirement. In this case investors optimize their withdrawal rate based on an expected retirement horizon without any consideration for discrete adverse portfolio events. Subsequent to the event, though, they need to re-optimize their withdrawal rate based on the same expected retirement horizon. We then calculate the probability of ruin for such an investor over the same five asset allocations as in the anticipated cost case study above. The only difference is that the investor does not adjust the optimal withdrawal rate to account for the possible occurrence of an $80,000 cost for health and aged-care costs at some stage during retirement.

Our results suggest, by way of example, that an investor who is relatively healthy and expects to live to 90 years of age with retirement savings invested in a balanced portfolio, and does not expect to pay any health/aged-care costs during retirement, will optimally withdraw around 4.36% of his or her portfolio value at the date of retirement each year (Exhibit 10). This equates to around $27,637 per year (and thus exceeds the ASFA Retirement Standard Modest lifestyle for a single person of $23,363 per year).

EXHIBIT 10

Fifth Percentile Annual Optimal Withdrawal Rates for Each of the Five Asset Allocation Portfolios without Anticipating Health/Aged-Care Costs Assuming a Given Life Expectancy

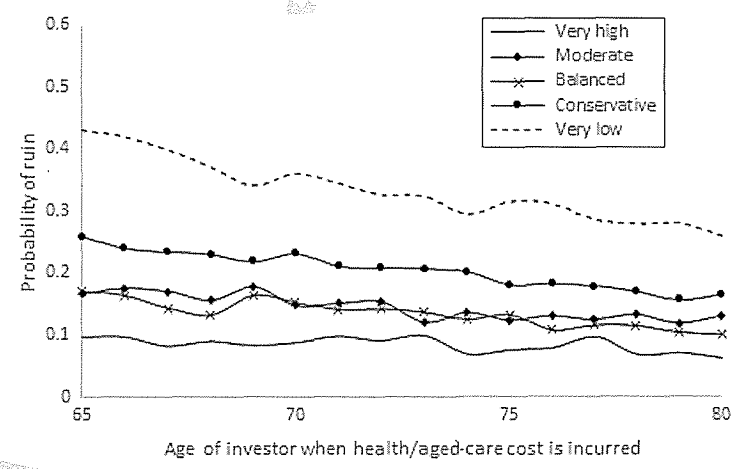
Life Expectancy	Portfolio	Withdrawal Rate	Withdrawal $
80	Very high	4.13%	39,121
	Moderate	5.75%	38,626
	Balanced	5.89%	37,344
	Conservative	6.19%	36,251
	Very low	6.24%	29,145
90	Very high	3.22%	30,470
	Moderate	4.20%	29,688
	Balanced	4.36%	27,637
	Conservative	4.70%	26,230
	Very low	4.23%	19,759
100	Very high	2.90%	27,640
	Moderate	3.89%	27,234
	Balanced	4.34%	26,981
	Conservative	3.64%	21,280
	Very low	3.55%	16,563

As shown in Exhibit 11, the probability of ruin for an investor with an investment horizon to 80 years of age dramatically increases for each of the five asset allocation strategies. The probability of ruin is higher for portfolio allocations that are weighted toward bonds and cash. The profiles fluctuate around a central trend which is an artefact of the bootstrap simulation process using historical data. The profiles have not been approximates using trend analysis: rather, we retain the raw results to avoid approximations.

Exhibits 12 and 13 depict the same optimization process and ruin profiles for investors who look to extend their retirement horizon to 90 and 100 years of age, respectively. In contrast to investors who anticipate significant heath and aged-care costs, the probability of ruin for all asset allocations actually increases, because the investors fail to adjust their spending rate during retirement to allow for an expected health and/or aged care cost liability. It should be noted that as the investment horizon increases, only the less conservative portfolios (very high, moderate, and balanced)

EXHIBIT 11

Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Unanticipated Health and Aged-Care Costs Incurred at Each Age – 80 year horizon

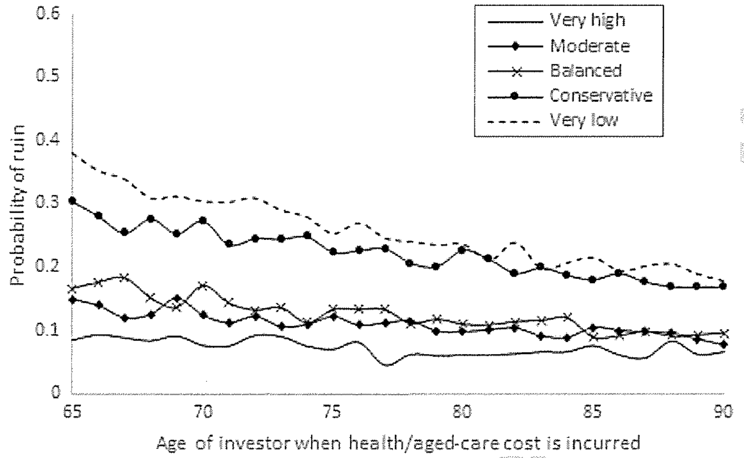


Investor initial age 50, retirement age 65, investment horizon age 80, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000 incurred at each age.

The probability of ruin represents the probability of depleting the retirement portfolio given an unexpected health/aged-care cost liability of $80,000 incurred at a particular year and the investor continues to live until 80 years of age. Optimal withdrawal rates for each asset allocation (based on risk tolerance) are used.

EXHIBIT 12

Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Unanticipated Health and Aged-Care Costs Incurred at Each Age – 90 year horizon



Investor initial age 50, retirement age 65, investment horizon age 90, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000 incurred at each age. The probability of ruin represents the probability of depleting the retirement portfolio given an unexpected health/aged-care cost liability of $80,000 incurred at a particular year and the investor continues to live until 90 years of age. Optimal withdrawal rates for each asset allocation (based on risk tolerance) are used.

eventually recover from the cost liability, such that the probability of ruin eventually converges to a value near the ruin probabilities predicted for investors who anticipate such costs.

This outcome suggests that the significant decline in the portfolio value after incurring an unexpected health or aged-care cost liability increases the probability of ruin when the portfolio is heavily weighted toward low-risk assets. At the other extreme of the asset allocation continuum, however, beyond a certain point where the portfolio is allowed to recover, the probability of ruin for higher-risk portfolio strategies plateaus or declines. The lower- risk strategies that are weighted toward bonds and cash do not have sufficient time for the portfolio to recover after an unexpected liability, with the investor drawing a modest income. Lower-risk investment strategies will inevitably lead to a higher probability of ruin for longer investment horizons.

So a higher-risk investment strategy through the decumulation phase appears to dominate the optimal investment approach for investors who incur a significant health or aged-care cost liability at some point during retirement, particularly when examining the investment behavior over long time horizons. For investors who have a higher chance of survival beyond their life expectancy and a low tolerance to risk, is there a mixture of strategies that can offer lower volatility while simultaneously reducing the probability of ruin? An approach modeled on a dynamic lifecycle investment philosophy that obtains the best of both worlds may be possible.

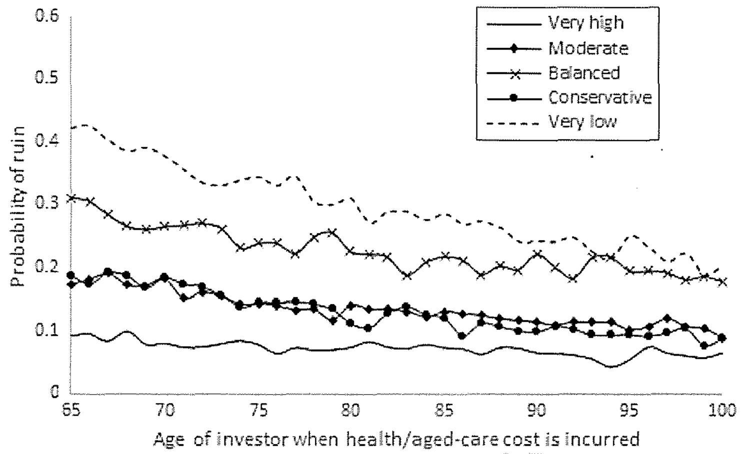
Dynamic Lifecycle Approach to Recover from Unanticipated Costs

It is fair to say that a great number of investors will fail to fully anticipate significant age-related health and/or aged-care costs during their retirement, and so will optimize their spending pattern to align with their portfolio level and life expectancy. Many investors will defer to the State to make up the shortfall in health and aged-care costs.

As social policy reform shifts the responsibilities for age-related costs to individuals, though, it is clear that the State will soon be unable to make up the entire difference. To account for the cost gap confronting an investor who fails to anticipate health or age-care costs, a key question is whether some form of dynamic asset allocation strategy during the accumulation and retirement phases can recover withdrawal rates to the same value as if the costs were anticipated.

Exhibit 13

Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Unanticipated Health and Aged-Care Costs Incurred at Each Age – 100 year horizon



Investor initial age 50, retirement age 65, investment horizon age 100, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000 incurred at each age. The probability of ruin represents the probability of depleting the retirement portfolio given an unexpected health/aged-care cost liability of $80,000 incurred at a particular year and the investor continues to live until 100 years of age. Optimal withdrawal rates for each asset allocation (based on risk tolerance) are used.

Dynamic asset allocation strategies have been shown to minimize the effects of sequencing risk during the accumulation phase. Basu, Byrne, and Drew [2011]; Pfau and Kitces [2013]; and Ang, Chen, and Sundaresan [2013] advocate increasing equity allocations if retirees are falling short in terms of maximizing their wealth. They show that there is a greater chance of a successful retirement, even if retirees experience an unfavorable market environment early, because a rising equity allocation through time will maximize their exposure when the market rebounds. Unfortunately, this dynamic asset allocation strategy requires a higher level of risk tolerance from retirees. However a product-centric strategy of higher-risk equity funds combined with a dynamic asset allocation approach can make such a strategy more tolerable for conservative retirees.

During the accumulation phase, portfolio adequacy based on a defined terminal wealth target can be optimally achieved using target-driven asset allocation strategies, such as a dynamic lifecycle strategy (DLC) strategy. The DLC strategy increases the allocation to riskier asset classes when workers' portfolio wealth is less than a defined adequacy target. The glide-path of a DLC strategy is not pre-determined because the asset allocation policy depends both on a worker's retirement date and on the performance of the portfolio relative to a retirement target. When the portfolio wealth is greater than an adequacy target, the allocation shifts toward more defensive assets; when wealth falls below the target, the portfolio shifts toward growth assets.

The DLC strategy is a flexible approach that preserves terminal wealth as the primary objective, particularly in the presence of sequencing risk. It is in sharp contrast to the static and deterministic allocation strategies of target risk funds (TRFs) and target date funds (TDFs), whose primary aim is to maintain a predetermined policy portfolio rather than terminal wealth.

The same approach can be deployed during the retirement phase, to preserve portfolio wealth within the constraints of keeping a minimum withdrawal rate and minimizing the probability of ruin over the investment horizon. These two competing constraints can be reconciled through the dynamic optimization approach discussed above, only with the added constraint regarding year-by-year ruin probability minimization.

The "drawdown dynamic lifecycle strategy" (DDLC) is partitioned into three investment periods. First, for the years leading to the occurrence of an unanticipated health or aged-care cost liability (an event such as high needs care or high pharmaceutical costs), the strategy is heavily weighted toward high-risk assets, so that Australian stocks dominate 90% of the portfolio. The rationale for this is that the objective of the investor is to continue to maximize wealth over the first 10 or so years of the retirement horizon. Consistent with lifecycle theory, the investor (now a retiree) should have sufficient time to recover wealth over this period if stock market performances have been unfavorable. Second, when the retiree enters the higher risk zone for incurring health or aged-care costs (beyond the age of 75) and then incurs a significant cost, the DDLC strategy switches to a second investment period of 10 years or until the "expiry" of the retiree, whichever is sooner. Third, the remaining partition extends from the second partition (i.e., 20 years after retirement) to the "expiry" of the investor. Each of the three partitions has different asset allocation rules.

We examine three DDLC strategies, each differing only by the proportion assigned to growth and defensive assets. For the second and third partitions in each of the three strategies, the below-target ruin portfolio is 100% in growth assets. The above-target ruin probabilities in the second and third partitions are provided in Exhibit 14.

The rationale for the increasing proportion of growth assets in the above-target ruin probabilities in each of the final two partitions is to reduce or at least stabilize the probability of ruin as the investment horizon stretches toward the investor's expiry date, so long as the withdrawal rate remains above the originally derived rate. Unlike other common asset allocation strategies, the DLC strategy uses performance feedback to control the asset allocation at any point in time.

All three DDLC strategies outperform the static conservative strategy in terms of minimizing the probability of ruin after incurring an unexpectedly large health/aged-care related cost. More specifically, the DDLC 2 strategy outperforms both the DDLC 1 and DDLC 3 strategies (Exhibit 15). The three DDLC strategies unsurprisingly converge to the constant conservative strategy probability of ruin profile after about 20 years of retirement. The DDLC 2 strategy is a more aggressive version of the other two, and invests heavily in growth assets during the period of highest vulnerability for retirees. In the 75–85 years of age period, imposing a significant cost impacts heavily on longevity risk, and without an aggressive portfolio recovery plan the probability of ruin remains very high (e.g., greater than 20% for a conservative investor). A probability of ruin of over 20% each and every year of retirement after a one-off health/aged-care cost burden could be psychologically debilitating. Preparing a dynamic recovery plan like the ones we have tested here can at least halve that probability and ensure that longevity risk is more manageable.

These results highlight that a DDLC-style approach can both augment portfolio recovery and minimize ruin probability over a long horizon in the event of health and/or aged-care costs, in the same way as in the accumulation phase, for a typical investor. It is important to note that the median values for higher-risk strategies will obviously dominate lower-risk strategies. But as shown in the analysis above, when stabilizing the probability of ruin becomes a major constraint, then the capacity to dynamically adjust investment strategies in response to this constraint and to the need to maintain a minimum income level above the ASFA Retirement Standard Modest lifestyle level appears to improve outcomes.

EXHIBIT 14

Drawdown Dynamic Lifecycle (DDLC) Strategy Definitions

	Below Target Portfolio	Second Partition above Target Portfolio	Third Partition above Target Portfolio
DDLC 1	100% Growth	60% Growth	40% Growth
	0% Defensive	40% Defensive	60% Defensive
DDLC 2	100% Growth	80% Growth	20% Growth
	0% Defensive	20% Defensive	80% Defensive
DDLC 3	100% Growth	50% Growth	20% Growth
	0% Defensive	50% Defensive	80% Defensive

DISCUSSION

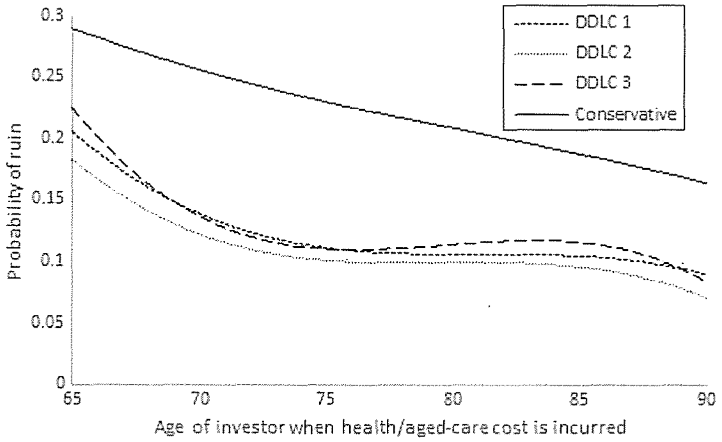
Sensitivity of Results to Initial Investment Portfolio Value

Clearly the probability of ruin is sensitive to the initial portfolio values used for the simulation. For instance, to demonstrate the degree of sensitivity, if we use the ASFA Retirement Standard Modest lifestyle for a couple of $33,664 per year with an initial portfolio balance that is twice the amount used in our initial model ($500,000), we observe the updated probability of ruin profiles in Exhibit 16.

The probability of ruin declines significantly with the high risk asset allocation strategy attracting

EXHIBIT 15

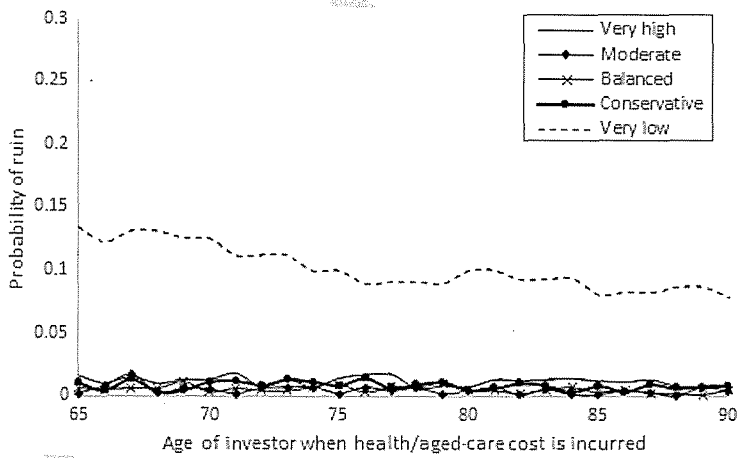
Probability of Ruin for an Optimized Withdrawal Rate for a Range of Drawdown Dynamic Lifecycle (DDLC) Asset Allocations with Unanticipated Health and Aged-care Costs Incurred at Each Age



Investor initial age 50, retirement age 65, investment horizon age 90, initial investment of $250,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000. Optimal withdrawal rate for an investor initially allocated to a "conservative" portfolio is used.

EXHIBIT 16

Probability of Ruin for an Optimized Withdrawal Rate for a Range of Asset Allocations with Known Health and Aged-care Costs Incurred at Each Age – 90 year horizon, ASFA Modest Couple, $500,000 initial investment



Investor initial age 50, retirement age 65, investment horizon age 90, initial investment of $500,000, salary $70,000, wage inflation 2%, price inflation 2.5%, pension contribution rate 9.5%, tax 15%, and health/aged-care costs of $80,000. Withdrawal rate of $33,664 per year used (ASFA Retirement Standard Modest lifestyle for a couple).

the greatest ruin profile over the investment horizon. Clearly initial portfolio value is the key driver for reducing the probability of ruin, however the degree of sensitivity is quite significant.

Accessing Housing Stock Wealth

The provision of funding through retirement may be augmented by accessing housing wealth. Retirees can monetize their residential home in a number of ways. First, they can downgrade their house to a less expensive or rental home to access at least some of the equity from their property (McNelis [2007] and Bridge et al. [2010]). Second, the retiree can adopt a "sell and stay" home reversion model where they sell their residence for an amount less than market value, but retain the right to continue living in the dwelling until they move out or die. Third, an alternative to the previous approach is the "stay and not sell" model, which involves the retiree taking out an additional loan (such as a second mortgage or a reverse-annuity mortgage) allowing the retiree to borrow cash against the value of their home that is repaid with interest when the house is eventually sold (from the estate of the retiree). In short, the results for the probability of ruin do not explicitly include the option to access residential housing wealth and so our predictive results provided above may be more conservative than what is observed.

CONCLUSION

The stochastic optimization/dynamic goal-oriented investment methodology has a number of attractive features:

- The model is extremely flexible and can accommodate almost any set of assumptions or features relating to existing types of pension arrangements. The model therefore has considerable practical potential.
- The methodology allows us to develop sensitivity and "what if?" experiments by changing key assumptions and observing how these changes affect our results. These exercises are obviously useful because they identify the key factors affecting results and gauge the response to particular assumptions.
- The model is naturally extended beyond the accumulation phase (the period up to retirement) to deal with the distribution (or post-retirement) phase. This is a necessary element of retirement modeling that has historically been disaggregated from accumulation phase modeling by retirement planning scholars.

We examined the probability of ruin for a range of investment strategies for investors who face expected and unexpected health and aged-care costs during retirement. Broadly, investors who anticipate health and aged-care costs suffer lower probability of ruin over the retirement horizon compared with investors who fail to account for such liabilities. However investors who fail to anticipate health and aged-care costs may be able to avoid ruin and indeed outperform a static investment strategy, if they adopt a form of drawdown dynamic lifecycle (DDLC) investment strategy. This naturally requires a higher risk tolerance than they may be able to bear, but it may also be the only way to avoid ruin.

ENDNOTES

This research was supported by the CSIRO-Monash Superannuation Research Cluster, a collaboration among CSIRO, Monash University, Griffith University, the University of Western Australia, the University of Warwick, and stakeholders of the retirement system in the interest of better outcomes for all. We are also grateful for the valuable input from the anonymous referees and the managing editor of the *Journal of Retirement*, Sandy Mackenzie.

[1]Unless specified otherwise, all dollar values expressed in the article are in Australian dollars (AUD). At the time of writing, 1 AUD = 0.72 USD.

[2]In this context "modest" refers to the absolute dollar value of the portfolio for a worker who has contributed for his or her entire working life. Compared to current actual female account balances, $250,000 is in fact quite high. For more on the gender-sensitive superannuation design, see Basu and Drew [2009b]).

[3]The algorithm needs input function values as well as the Jacobian, which we do not assume to be constant for our nonlinear model. We approximate the Jacobian using finite differences re-evaluated at the commencement of each major iteration (i.e., the major percentile terminal values).

[4]The other key inputs for the representative investor is that her initial age is 50, retirement age is 65, investment horizon is to the age of 95, initial investment is $250,000, initial salary of $70,000, wage inflation is 2% per year, price inflation 2.5% per year, pension contribution rate 9.5% per year, tax 15%, and aged-care costs of $80,000 (aligned with the average annual cost of a high-care facility bed. See Ansell, et al. [2012]).

[5]Note, however, that if health care expenditures were very small, the reduction in the probability of ruin from an extension of the retirement period would not be significant.

[6]The ASFA Retirement Standard benchmarks the annual budget needed by Australians to fund either a comfortable or modest standard of living in the post-work years,

for more information see: http://www.superannuation.asn.au/resources/retirement-standard.

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THE TWO FACES
of investment performance and risk

ROBERT J BIANCHI SF Fin, Associate Professor of Finance, Griffith Business School
MICHAEL E DREW SF Fin, Professor of Finance, Griffith Business School
MICHAEL D EVANS, Vice President, Academic at Kaplan International, Australia
ADAM N WALK SF Fin, Research Fellow, Griffith Business School

Investment concepts are generally taught, learnt and spoken about among professionals in time-weighted terms. According to this view of the world, returns are the sole determinant of performance and risk, and a given return has an identical impact no matter its timing. While appropriate in certain circumstances, time-weighted returns (TWRs), and the performance and risk measures derived from them, provide an incomplete picture when evaluating certain practical financial problems like retirement investing. This paper discusses the distinction between time-weighted returns (TWRs) and more comprehensive measures, and compares a number of extant investment strategies employing a range of performance and risk measures from each category. We find that time-weighted measures overlook important aspects of retirement investing, whereas wealth-denominated, target-relative measures more accurately capture the dynamics of retirement investing. Thus we see the two faces of investment performance and risk.

Defined contribution (DC) plans have a responsibility to earn investment returns for their plan members to fund their retirement. It is therefore not surprising that returns-based performance and risk measures are of central concern to fund trustees, managers and plan members alike. While such measures will always have a place in fund governance, management and communications, we question whether a singular focus on these measures obscures a more complete understanding of retirement outcomes. We ask ourselves: In retirement investing, how should performance and risk be measured, incorporated into plan design, and communicated? This research sets out to address these questions by comparing time-weighted and wealth-denominated measures of performance and risk for a range of competing asset allocation strategies. The evaluation of investment strategies is an important function of plan sponsors/ trustees and managers, and we use a comparison of these two measurement bases to illustrate points both about the measurement basis, and what this means for DC investing. We also take the next step, and explore the implications for investment governance, a function that has been under scrutiny internationally in DC plans in recent times.

Our findings suggest neither measure is better, rather, judicious use of both time-weighted and wealth-denominated measures should be used to evaluate the success (or otherwise) of a retirement savings plan.

We explore what we describe as the two faces of investment performance and risk in retirement investing through a number of comparisons:

> the relative evaluations that result from using time- versus wealth-denominated conceptions of performance and risk;

> the relative performance of competing asset allocation strategies.

In doing this, we set out to show that the risk measurement basis is critical in the evaluation process and, when the measurement basis is appropriate, new perspectives regarding retirement outcomes emerge.

Data and methodology

Data

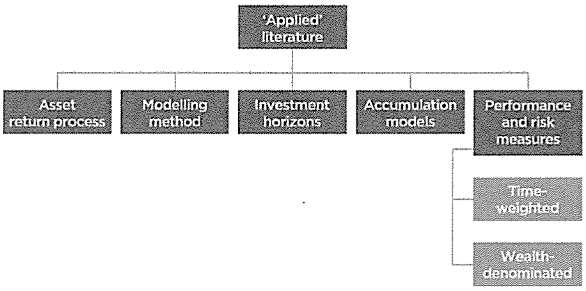
The data used in this study are the well-known, and commonly used, monthly stock and Treasury bill (T-bills) returns maintained by French (2012).[1] We justify our focus on stocks with the logic that, irrespective of the actual asset allocations of a typical long horizon investor, portfolios with a material allocation to stocks are driven first and foremost by the performance of stocks, especially in down markets. It is therefore important to understand the performance of stocks above all others. T-bills represent a safe asset that can be used to moderate the risk of stocks.

Methodology

In this study we confine our consideration to what Booth (2004) describes as the 'applied' stream in the pension finance literature. Scholars who pursue this path tend to approach the research question empirically, with simulation techniques being a common methodological choice (Booth 2004). We have sympathy for this manner of approaching financial research, and we pursue an empirical, simulation-driven methodology in this paper. We postulate that outcomes from DC plans are largely path dependent and are generally not best understood using closed-form solutions.

FIGURE 1: Five dimensions in 'applied' literature

This figure shows (in summary form) the five dimensions of this study.



These five dimensions are handled as follows:

1. Asset return process — Because the views of scholars on the asset return processes driving financial data are mixed, we use a modelling method which treats the asset return process as an empirical matter.
2. Modelling method — The modelling method selected in this study is a form of block bootstrap simulation (Künsch 1989). We employ the stationary bootstrap of Politis and Romano (1994), in which the block size is a geometrically distributed random variable, because the technique is shown to be less sensitive to block size misspecification.[2]
3. Investment horizons — We examine a range of investment horizons, with a specific emphasis on the 40-year horizon as a proxy for a lifetime of retirement savings (or, the accumulation phase).
4. Accumulation model — We consider a simple accumulation model where the hypothetical investor makes contributions at the rate of 9 per cent per annum (p.a.) of income (credited on a monthly basis) where income grows at the rate of 3 per cent p.a. (applied monthly). Earnings (and median account balanced data) are used as estimates of income (and initial wealth) at time $t = 0$ for the ages that correspond to the investment horizons examined (see Table 1 and Appendix A).
5. Performance and risk measures — Measures can be broadly categorised as either time-weighted measures or wealth-denominated (or money-weighted) measures. Time-weighted rates of returns are defined as a measure of the compound rate of growth in a portfolio. Dichev and Yu (2011, pp. 250–51) define the money- or dollar-weighted return 'as the rate of return that equates the discounted ending asset value to the sum of the initial assets-under-management and the present value of the capital flows realised over the life of the fund.'[3] This is a key distinction between the two measurement bases.

TABLE 1: Earnings and account balance data

This table presents earnings and related account balance data in order to approximate initial wealth (W0) for various horizons. A more complete table (including details regarding data sources) is available in Appendix A.

Investment horizon (years)	**40**
Assumed age	**25**
Median earnings data	25,000
Raw median account balance	4,757
Median account balance	5,000

TABLE 2: Summary of performance and risk measures

This table presents the four time-weighted and four wealth-denominated measures used throughout this study under corresponding headings. The full specification of these measures can be found in Appendix B.

Time-weighted	Wealth denominated
Mean	Median RWR
Standard deviation	Probability of shortfall
Sharpe ratio	Expected shortfall
Negative return 1 in x years	Sortino ratio

Evaluating outcomes using the retirement wealth ratio (RWR)

The challenge with return or dollar-based terminal wealth measures of performance is that neither is particularly informative for the investor in terms of what performance means to their spending power in retirement. Baker et al. (2005), for example, argue that defined contribution plans should be measured in terms of their ability to generate sufficient retirement income, and Basu and Drew (2009, 2010) contend that a plan member's expectations will somehow be related to their salary immediately prior to their retirement. We therefore adopt Basu and Drew's (2009, 2010) retirement wealth ratio (RWR_T), which is calculated by dividing terminal wealth (W_T) by income at time T. The RWR_T provides as a way of relating terminal wealth to some benchmark for the plan member's post-retirement expectations.

Asset allocation

To understand the relative performance of the major DC investing approaches pursued in Australia and the United States we consider the following investment strategies:

1. 100% stocks — The all-stock portfolio is a benchmark for a wealth-maximising, long-horizon investment approach advocated by scholars such as Siegel (1994).
2. 100% cash — In the same way that the all-stock portfolio provides the outer limits of performance for an investment portfolio, the cash portfolio gives an indication of the performance of a zero-risk portfolio.
3. Balanced — Target risk funds (such as balanced strategies) are widespread in jurisdictions where DC plans predominate, for example, in the United States and in Australia (where they remain the cornerstone of superannuation fund default offerings). In our two-asset world, we assume that this balanced fund has a constant allocation to stocks of 60 per cent and an allocation to cash of 40 per cent.[4]
4. Target-date fund — The target-date fund considered in this paper has the following design: for the first 20 years, the glidepath has a constant allocation to stocks of 80 per cent; and from year 20, the allocation to stocks falls linearly *on an annual basis* from 80 per cent to 56.25 per cent at retirement.
5. Dynamic lifecycle strategy — The dynamic strategy studied in this paper will be similar to that studied by Basu et al. (2011), i.e. it is a dynamic asset allocation process informed by a predetermined target (7 per cent p.a.). In the interests of brevity we refer readers to that study.

Empirical evidence

This study compares five different asset allocation strategies on two competing bases, in order to provide insights as to the importance of performance and risk measurement to retirement investing. Again, in the interests of brevity, we show only those results referred to in the text. All output for this study is available from the authors upon request.

Time-weighted performance and risk

Table 3 reports the four time-weighted performance and risk measures for the five investment strategies for a 40-year investment horizon.

TABLE 3: Time-weighted performance and risk measures

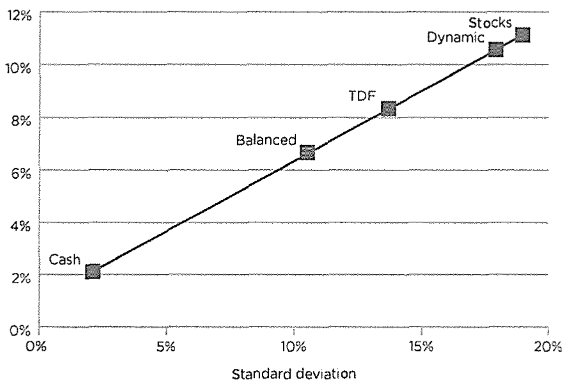
This table presents four time-weighted measures of performance and risk calculated using the stationary bootstrap method for a 40-year investment horizon. Estimates for mean and standard deviation (St. Dev.) are expressed in percentage terms, and estimated Sharpe ratios (as the name suggests) are ratios.

Strategy	Mean	St. Dev.	Sharpe	Negative return
Stocks	10.93%	18.51%	0.4009	1 in 3.6 yrs
Balanced	7.96%	11.10%	0.4009	1 in 4.2 yrs
TDF	9.00%	13.77%	0.3987	1 in 3.8 yrs
Dynamic	10.50%	17.59%	0.3974	1 in 3.6 yrs
Cash	3.51%	0.81%	0	Never

We see in Table 3 that in each case the return-for-risk trade-off is virtually identical for each strategy. This broadly is consistent with finance theory: returns should be higher for those willing to accept more risk. Figure 2, for example, shows a classic capital market line formed by the five strategies, ranging from cash in the bottom left to stocks in the upper right.

FIGURE 2: Return-risk spectrum

This figure plots the five strategies on a Cartesian plane with mean return on the y-axis and standard deviation on the x-axis. A linear trend line is also plotted.



Viewed from a holistic perspective, Table 3 (and associated illustration in Figure 2) highlights a key issue. Because of the nature of the measures, it is only possible to decide between our four alternatives based on risk tolerance alone. This leads the hypothetical investor to make choices on the basis of something which is often hard for the individual to determine: their own risk tolerance. Those with greater risk tolerance will be drawn to higher return strategies whereas those with lower risk tolerances will likely favour lower risk options. In any case, the relevant question is: Is the average investor best served by trying to resolve their risk tolerance and then make their investment selection? Or, would the investor be better served by considering factors which are far easier for them to determine — e.g. their preferred retirement lifestyle — and then making decisions based on this?

This point leads to our next, and perhaps most significant, point. Using the measures in Table 3, what kind of sustainable income might their accumulated savings support? Indeed, what might a reasonable estimate of the investor's accumulated savings be? Clearly, looking at these measures in isolation, it is virtually impossible to answer these questions. We ask ourselves: Is there another, more informative, way of measuring performance and risk for a retirement investor?

Wealth-denominated performance and risk

When investing for retirement we are generally seeking to generate enough terminal wealth to fund an adequate income stream. In this sense the plan participant may not be interested in the pure maximisation of wealth. Perhaps, then, we are willing to forego potential upside in returns in order to create some certainty around a particular level of terminal wealth. We now turn to comparing our asset allocation strategies using the four wealth-denominated performance and risk measures reported in Table 4.

TABLE 4: Wealth-denominated performance and risk measures

This table presents a summary of four wealth-denominated measures of performance and risk calculated using the stationary bootstrap method for a 40-year investment horizon. Median *RWR*s are expressed as *RWR* units (x times final salary), probability of shortfall as percentages, expected shortfall as *RWR* units (x times final salary), and Sortino ratios as ratios. Complete results can be found in Appendix B.

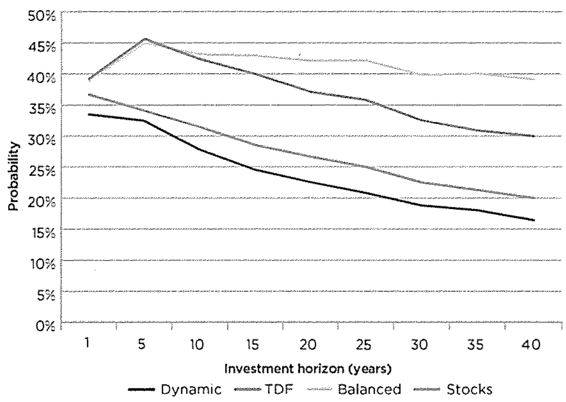
Strategy	Median RWR	P (shortfall)	E (shortfall)	Sortino
Stocks	20.41	20%	0.67	9.97
Balanced	11.35	39%	1.06	1.35
TDF	13.73	30%	0.82	3.35
Dynamic	17.94	16%	0.56	7.95
Cash	4.21	100%	5.48	-0.98

Table 4 demonstrates the performance differences that a wealth-denominated lens yields. The results highlight the potential for dramatic differences over a 40-year horizon. For ease of comparison, each of the three target-relative measures, for four of our five asset allocation strategies, is plotted against the investment horizon in Figure 3.

FIGURE 3: Comparison of investment strategies — Target-related measures

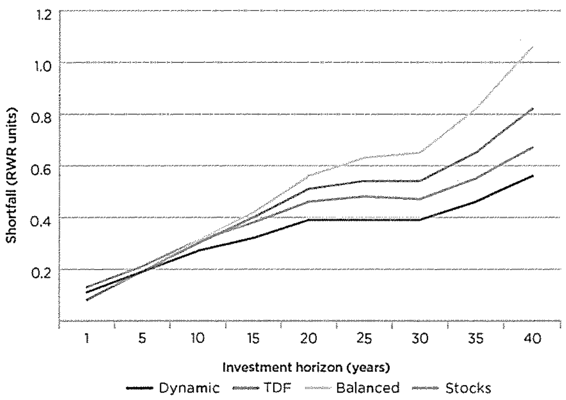
Using the stationary bootstrap simulation method, we report three target-relative measures. Panel A presents the probability of a shortfall expressed in percentage terms, Panel B shows the expected shortfall in RWRT terms, and Panel C presents the Sortino ratio as a ratio of above-target reward to below-target variation. We exclude the cash strategy in the interests of readability.

PANEL A: Probability of a shortfall



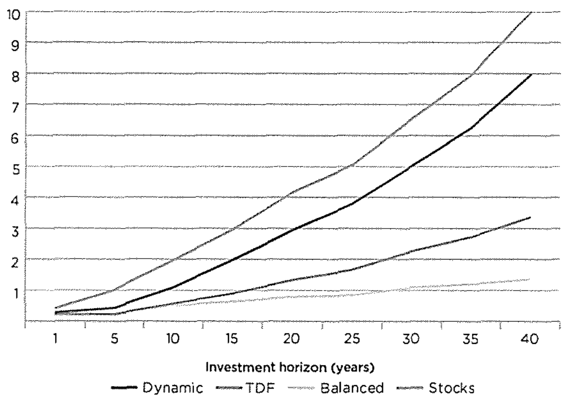
Two themes emerge from a review of the probability of shortfall estimates shown in Panel A of Figure 3. First, we see a relationship between the allocation to risk assets and the absolute level of shortfall probability. Generally speaking, the higher the allocation to risk assets the lower is the absolute level of probability over all horizons. Second, as the allocation to risk assets increases, the shortfall probability declines as the investment horizon lengthens. That is, the gradient of the series is generally steeper for those strategies with higher risk allocations.

PANEL B: Expected shortfall



In Panel B, we see that the average shortfall increases with the investment horizon for all strategies, consistent with the nature of our accumulation model and with our intuition. As returns, contributions and salary growth compound through time, the range of outcomes widens, and the average shortfall increases when we are below the target *RWR*. The surprising trend in Panel B is perhaps the ordering of the strategies. For a higher allocation to risk assets, one might expect larger potential drawdowns and a larger average shortfall. But, in reality, the stock strategy would be in shortfall less often than, say, the balanced fund and, when it is, it would be in shortfall by a lesser amount because of the cumulative effect of the return premium over the target rate of return.

PANEL C: Sortino ratio



For the Sortino ratio (Panel C) our estimates accord more closely with our expectations, and with the findings of other studies (Sinha and Sun 2005). First, the Sortino ratios for all strategies increase monotonically with investment horizon. We expect these results because, as shown earlier, positive outcomes grow at a greater rate than negative outcomes as the investment horizon lengthens. This positive relationship between Sortino ratio and horizon is also consistent with the only other study in the time diversification literature that considers the measure (Sinha and Sun 2005). In a target-relative paradigm, we find that pursuing a dynamic strategy causes us to forego potential upside in returns in exchange for materially altering the downside risk characteristics of a portfolio when compared to a static alternative.

Implications for investment governance

The discussion above presents a number of implications for investment governance. First, for plan sponsors/trustees it might be useful to define an investment target for fund members. In order to ensure alignment between fund governance, investment strategy and member communication it appears appropriate to express this target in terms meaningful to the member. In this regard, the *RWR* discussed above appears to be more appropriate than a pure return objective because the former explicitly acknowledges that terminal wealth is a function of more than just returns.

Second, once the target has been defined, success should be measured and communicated in these terms. This will allow trustees to appreciate how the fund is serving its members, how the investment arrangements are contributing to this goal, and how members are progressing towards their target. The objective is ultimately to use these measures to make the right decisions. We have shown here that for retirement investing, time-weighted measures are only part of the equation.

Third, if the reader accepts the arguments presented above, it seems sensible to maintain complete alignment between the investor's target and the investment arrangements. If the target is paramount — as we would argue — then why not design an investment strategy that is target-aware? The dynamic strategy analysed in this paper is a simple, formulaic version of such a strategy. Our results suggest that such a strategy achieves superior money-weighted performance with satisfactory time-weighted performance. In practice, the challenge with such a strategy is that changes in asset allocation may be contrarian (e.g. buying risk assets in poor market conditions), and other performance measures (e.g. peer-relative performance) less favourable.

Finally, when it comes to investment governance, both types of measures have their place. It is critical that boards of trustees and their advisers know when to use the appropriate measurement basis. For example, TWRs are appropriate for tasks like investment manager evaluation. On the other hand, wealth-denominated measures would appear to provide a better measurement of the success of a superannuation fund in meeting member goals, in designing and evaluating investment strategies, and in reporting to plan members.

Appendix A

Earnings and account balance data

This table presents earnings and related account balance data in order to approximate initial wealth (W_0) for various horizons. Row one shows Bureau of Labour Statistics (BLS) (2009) median earnings data for the fourth quarter of 2008 (annualised, rounded). Row two shows raw Employment Benefit Research Institute (EBRI) (2009) median account balance data that corresponds to the annualised BLS earnings data in row one (Only includes 401(k) accounts. Previous employer accounts and IRAs are excluded). Row three shows the EBRI data rounded to the nearest thousand dollars. The rounded data is used as initial wealth (W_0) in the analysis in this paper. Row four shows data that was sourced to validate the account balance data shown in rows two (in raw form) and three (in rounded form). The data was obtained from the US Census Bureau (2012) and represents the median value of retirement accounts by age (including IRAs, Keogh accounts, 401(k), 403(b)). Investment horizon and assumed age are expressed in years. All other data are expressed in dollars.

Investment horizon (years)	**40**	**35**	**30**	**25**	**20**	**15**	**10**	**5**	**1**
Assumed age	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**64**
Median earnings data	25,000	35,000	39,000	42,000	42,000	43,000	43,000	43,000	33,000
Raw median account bal.	4,757	10,108	15,458	34,176	52,893	62,242	71,591	72,713	73,834
Median account balance	5,000	10,000	15,000	34,000	53,000	62,000	72,000	73,000	74,000
Validating account bal.	N/A	10,000	23,000	36,000	51,500	67,000	82,500	98,000	77,000

Appendix B

Time-weighted measures

Mean $\bar{r}=\frac{1}{n}\sum_{t=1}^{n} r_t$ [1]

where r_t = is the arithmetic return at time t

$\bar{r}$ = is mean of arithmetic returns r_t

n = is the number of observations

Standard deviation $s=[\frac{1}{n}\sum_{t=1}^{n}(r_t-\bar{r})]^{1/2}$ [2]

where s is the standard deviation of returns and the remaining notation accords with that outlined for equation [1].

Sharpe ratio $SR=^{\bar{r}_i-\bar{r}_{cash}}/\bar{s}_i$ [3]

where $\bar{r}_i$ = is the average over 10,000 simulated paths of mean, $\bar{r}$, for investment strategy i

$\bar{r}_{cash}$ = is the average over 10,000 simulated paths of mean, $\bar{r}$, for the cash only investment strategy (i.e. the risk-free portfolio)

$\bar{s}_i$ = is the average over 10,000 simulated paths of standard deviation, s, computed using equation [2] (Sharpe 1966).

The final time-weighted measure to be considered is the frequency of loss measure, which is typically expressed as follows: A negative return every 1 in x years. There are several ways to compute such a measure, for example, using simulation methods or by. It is our understanding that the frequency is inferred from the standard normal distribution using mean and standard deviation.

Wealth-denominated measures

Median RWR is the middle outcome i.e. where 50 per cent of outcomes are better and 50 per cent of outcomes are worse.

Prob. of Shortfall $LPM_{\lambda}=\frac{1}{n}\sum_{t=1}^{n} Max[0,(RWR_{target}-RWR_t]^{\lambda}$ [4]

where RWR_{target} = the target outcome

RWR_t = is the outcome for the tth observation

n = is the number of observed RWR outcomes

Max = is the maximisation function that selects the larger of the two quantities

λ = the degree of the lower partial moment. In this case, λ=0

Expected shortfall $LPM_{\lambda}=\frac{1}{n}\sum_{t=1}^{n} Max[0,(RWR_{target}-RWR_t]^{\lambda}$ [5]

where RWR_{target} = the target outcome

RWR_t = is the outcome for the tth observation

n = is the number of observed RWR outcomes

Max = is the maximisation function that selects the larger of the two quantities

λ = the degree of the lower partial moment. In this case, λ=1

Sortino ratio SoR=RWRt-$RWR_{target}/(LPM_2)^{1/2}$ [6]

where $LPM_2=\frac{1}{n}\sum_{t=1}^{n} Max[0,(RWR_{target}-RWR_t]^2$

and RWR_{target} = the target outcome

$\overline{RWR}_t$ = is the mean of n RWR outcomes

n = is the number of observed RWR outcomes

Max = is the maximisation function that selects the larger of the two quantities

Acknowledgements

This research was supported by Kaplan Australia. We acknowledge and thank Kaplan Australia for their support, particularly Rob Regan and Brian Knight, and members of the Kaplan Academic Committee. We acknowledge participants at the AIST/ACFS Research Symposium (3 December 2013, Melbourne) and the Financial Advice in Super Symposium, Growing the Advice Pie (7 February 2014, Melbourne) for their comments on the paper. Finally, we thank Professor Kevin Davis (Managing Editor, *JASSA*) and an anonymous reviewer for comments that have improved the paper. Of course, any remaining errors are our responsibility. The views expressed herein are those of the authors and are not necessarily those of Kaplan Australia.

Endnotes

1 We thank Kenneth French for making the Fama and French portfolio data available on his web page: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

2 We employ a further three simulation methods to validate the findings of this study: (1) Monte Carlo simulation; (2) Efron (1979) bootstrap; and (3) the block bootstrap proposed by Politis and White (2004) and modelled using Patton's (2012) Matlab code. Of these three methods, the first two implicitly assume that the asset return process follows a random walk whereas the last method uses an algorithm to estimate the optimal block size based on the data. The results from all methods validate those reported in this paper, and accord with our expectations.

3 Throughout this research we use the following terms loosely and interchangeably: 'wealth-denominated', 'money-weighted' and 'dollar-weighted.' While technically different, these labels share a particular characteristic that is of overriding interest in this research: they each focus explicitly on the wealth earned. As suggested by Dichev and Yu (2011), 'money-weighted' and 'dollar-weighted' returns look at the return that equates discounted terminal wealth to the present value of cash flows. 'Wealth-denominated' measures look at wealth (often expressed in terms of a target), which is in turn a function of returns, contributions etc. In this sense, each of these measures incorporates the influence of intermediate cash flows. Time-weighted measures — the other type examined in this paper — do not; hence we have a dichotomy.

4 Recent anecdotal evidence suggests that Australian superannuation funds may be lowering the overall level of risk in their default MySuper options. This fact makes a 60 per cent/40 per cent investment strategy a reasonable approximation of the Australian institutional setting.

5 The Australian superannuation regulator — the Australian Prudential Regulation Authority (APRA) — is proposing the introduction of a similar measure in its draft Reporting Standard SRS 700.0: Product Dashboard (Australian Prudential Regulation Authority 2013). The calculation of this measure is, in turn, based on joint research by peak bodies the Financial Services Council and the Association of Superannuation Funds of Australia entitled *Standard Risk Measure Guidance Paper for Trustees* (Financial Services Council/Association of Superannuation Funds of Australia 2011). The measure proposed in the joint research is an estimate of the expected number of negative returns over a 20-year period. The methodology suggests that a trustee would need to develop a set of capital market assumptions (return, volatility, correlation) for the asset classes that comprise the specified superannuation option(s) in order to forecast a forward-looking return distribution of the overall investment option. From this distribution, the trustee computes the probability of a negative return over one year and then multiplies the probability by 20 to arrive at the estimated number of negative years in 20.

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Keywords: time diversification, risk, investment horizon.

THE TIME DIVERSIFICATION PUZZLE: *why trustees should care*

ROBERT J BIANCHI F Fin, Senior Lecturer, Griffith Business School, Griffith University
MICHAEL E DREW SF Fin, Professor of Finance, Griffith Business School, Griffith University
ADAM N WALK F Fin, Postdoctoral Research Fellow, Griffith Business School, Griffith University[1]

For 50 years, the time diversification debate has sought to understand the essential relationship between risk and investment horizon with little resolution. The answer seems to depend in part on how one views risk. This paper seeks to show that while the time diversification puzzle remains unsolved, the debate itself provides timely food for thought for trustees in setting fund investment policy and for designing defaults, in particular.

Time diversification — the notion that extending the investment horizon reduces risk — has been one of the most hotly contested ideas in finance since its first formal treatment by Samuelson (1969). Since then, nearly 100 scholarly papers have been produced on the subject, all to no avail. That the relationship between risk and investment horizon remains unresolved surely confirms the status of time diversification as one of finance's most enduring puzzles.

Conventional wisdom suggests that investment risk decreases as the time horizon increases. A large number of empirical studies support this idea, finding that the standard deviation of annualised returns falls over time. Entire books have been dedicated to communicating to a popular audience this idea that risk is tamed by time: for example, Siegel's (1994) *Stocks for the long run: A guide to selecting markets for long-term growth.* The widespread acceptance of the supposed inverse relationship between risk and time has led many in academe and industry to suggest that time diversification is more than just conventional wisdom, and has instead graduated to become a 'stylised fact' of modern finance.

So if this inverse relationship between risk and time horizon is so far beyond doubt then where is the puzzle? While many studies — including this one — confirm that the standard deviation of annualised returns decreases over time, studies also find that the standard deviation of cumulative returns does not diminish over time. In fact, if we frame risk in these terms, we find that dispersion actually increases over time. Figure 1, for example, shows these first two conceptions of risk plotted against investment horizon. Samuelson (1969) began the debate by asserting that there is no relationship between risk and investment horizon, arguing that risk is constant with investment horizon being a function of risk preferences.

FIGURE 1: Contradictory evidence

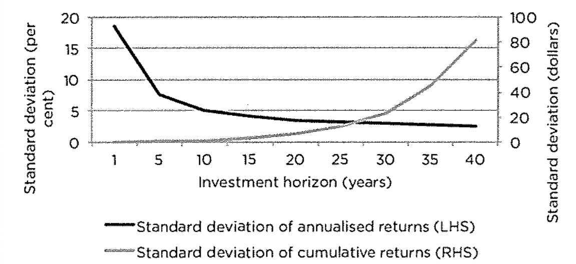


Figure 1 plots the standard deviation of annualised returns, in percentage terms, on the left vertical axis and the standard deviation of cumulative returns, in dollar terms, on the right vertical axis. Both series are plotted against investment horizon.[2]

This contradiction strikes at the heart of the time diversification puzzle. How is it that two versions of the one statistical measure of dispersion — standard deviation — give us opposite answers regarding the relationship between risk and time? Are risk and time negatively related — the received position — or positively related? Or is Samuelson (1969) right? What causes these seemingly contradictory outcomes? This paper is motivated by this contradiction at the heart of the time diversification puzzle, a contradiction for which the academy has no satisfactory answer as yet.

The time diversification literature

After Markowitz's (1952) groundbreaking work on portfolio choice in a one-period setting, scholars began to consider the portfolio selection problem in a multi-period setting like that encountered with practical investment problems. Chief among these scholars was another Nobel Prize winner Paul A Samuelson who considered the problem in a multi-period setting using expected utility theory. Samuelson's (1969) work is of particular interest to us for two reasons. First, he was among the first to bring the genius of Markowitz's (1952) work into a multi-period setting which, by itself, is remarkable.[3] Second, and particularly germane to this paper, Samuelson (1969) initiates the time diversification debate by considering whether the concept of diversification works with time, in the same way as it does among assets or securities (cf. Markowitz, 1952). In order to study the existence of time diversification, Samuelson (1969) selects the classical expected utility theory as his framework of choice. Expected utility theory is thus the point of departure for this debate, and all other competing streams or schools of thought tend to emerge at least in part as a reaction to Samuelson's (1969) work.

Samuelson (1969) isolates the relationship between risk and time by observing the optimal allocation to risk assets with horizon, based on three assumptions. While a number of proponents confirm the mathematical certainty of his findings, even more scholars — including some who are otherwise advocates of expected utility theory — call into question Samuelson's (1969) assumptions. In fact, it is Samuelson's (1969) three assumptions that provide later scholars with oxygen to keep the time diversification debate burning. While a comprehensive review of the literature identifies four schools of thought, this paper will only consider Samuelson's (1969) original framework — because of its three assumptions — and what was described by Booth (2004) as the 'applied' stream.[4]

The 'applied' stream in the time diversification debate is defined more by what it's not, than what it is. While the applied stream is a somewhat nebulous confection of studies, there is the faint semblance of a unifying theme. Scholars who pursue this path tend to approach the problem of time diversification empirically, and without resting on a theoretical edifice in the way that Samuelson (1969) does. Simulation techniques are also a common methodological choice as Booth (2004) suggests. Parallel to the time diversification debate, a rich literature on risk measures has emerged. Leaning on this literature, applied scholars tend to define risk in a certain way — for example, value at risk — and then proceed to estimate their selected risk measure over a number of horizons of different lengths. Scholars then draw conclusions about the presence or otherwise of time diversification by applying reasoning to these estimates. Naturally, it is possible to define risk in many ways and so the applied stream has tended to grow as new conceptions of risk emerge. Some scholars have even developed measures purely for the purposes of analysing the time diversification question.

Through time, in the time diversification literature we have seen a quest for the measure of risk that properly isolates the relationship between risk and time horizon. At the turn of the century, Kritzman (2000, p. 50) remarked wistfully that 'for many the time diversification debate has degenerated into a referendum on the meaning of risk'. We agree that the debate has become, and remains, a referendum on risk and that, in Kritzman's (2000, p. 50) words, such a referendum is to some extent '... futile'.

On the other hand, is a focus on risk necessarily a bad thing? We argue that such a focus on risk is desirable provided trustees resolve their attitude to risk, set investment policy with this frame in mind, and measure and monitor performance in a way consistent with the risk frame. Before we consider the most appropriate risk frame we briefly outline why this debate should be of interest to trustees.

The relevance of the time diversification debate for trustees

While a review of the literature shows that the puzzle remains largely unresolved, there are several conclusions that have emerged from the debate that should interest trustees. First, as we have shown, much of the time diversification debate is about risk, and how it is framed. In fact, a review of the time diversification literature shows that the relationship between risk and investment horizon depends on one's view of risk.

It is thus important that trustees resolve how they conceive risk before turning their minds to other important aspects of their role like setting investment policy and fulfilling the investment governance function. For example, if one views risk as the standard deviation of returns — as much of the industry appears to — this might lead to a different approach to investment policy than for a trustee that sees terminal wealth adequacy as the objective.

How one views risk also has implications for investment governance. If trustees see adequacy as the key objective of their fund, then performance expressed in terminal wealth terms is more informative than returns-only measures. According to this model, trustees would also need to consider other determinants of terminal wealth — like contribution rates — in addition to returns. In this scenario, while wealth becomes the central focus, returns remain an important measure of the success for the underlying investment program. Governance may therefore need to become multi-dimensional.

The real debate

With very few exceptions, the entire time diversification debate is conducted in a returns-only framework. Risk is thus seen through the narrow lens of returns. Contributions and other factors (e.g. salary growth) are almost completely overlooked. Trustees of Australian superannuation funds — whose members contribute at a minimum rate of 9 per cent per annum — would identify this as a significant deficiency. As trustees well know, pension finance is about wealth (the outcome), not only about returns as some literature would have us think.

Without considering realistic accumulation models, the time diversification debate, despite its understandable focus on the relationship between risk and investment horizon, largely ignores recent pension finance research. Basu and Drew (2009), for example, highlight the so-called 'portfolio size effect' which sees a rapid rise in portfolio size as retirement approaches, due to the combined effects of returns, contributions and salary growth. This portfolio size effect magnifies the potential effects of sequencing risk (Macqueen and Milevsky 2009; Basu, Doran and Drew 2012, Doran, Drew and Walk 2012): the risk of experiencing an inopportune sequence of returns.

Therefore, the dynamics of superannuation investing means that a minus 25 per cent return, for example, has different wealth impacts depending on the timing of the return. For example, the impact of the global financial crisis (GFC) — an example of sequencing risk realised — on those in their late 50s/early 60s has been devastating in wealth terms. In the next section we will provide a simple example of the dynamics which we argue the time diversification debate ignores; dynamics which are of great interest to trustees.

A practical example

In order to bring to life these dynamics we consider the experiences of two hypothetical investors:

> **Late 30s** — considers the experience of an individual who begins their retirement saving in their mid-20s with an account balance of zero dollars, and contributes at a rate of 9 per cent per annum for 13.5 years until their late 30s. Over the period their salary grows at a rate of 4 per cent per annum from $40,000 to $68,579.

> **Near retirement** — considers the experience of an individual who continues saving from their early 50s with an account balance of $100,000, and contributes at a rate of 9 per cent per annum for 13.5 years until near retirement age. Over the period their salary grows at a rate of 4 per cent per annum from $60,000 to $102,868.

The only differences between these two examples are their starting salary levels and their initial wealth. Comparing these hypothetical investors allows us to consider the differential impacts of identical returns at different stages of the investing lifecycle. To draw out the importance of the sequence of returns we look at three accumulation paths derived from the one set of synthetic balanced fund returns:

> **Actual path** — the actual path uses balanced fund returns as they occurred over the period January 1999 to June 2012.

> **Reverse path** — the reverse path uses the actual returns but in reverse order. The GFC would therefore have occurred early in the accumulation phase of the hypothetical investor in question.

> **Average path** — the average return path uses the periodic arithmetic mean for the return series for each period. In this sense, it is as if the investor earned the average return for each period.

We plot these three paths for each of the hypothetical members in Figures 2 (Late 30s) and 3 (Near retirement).

FIGURE 2: Late 30s

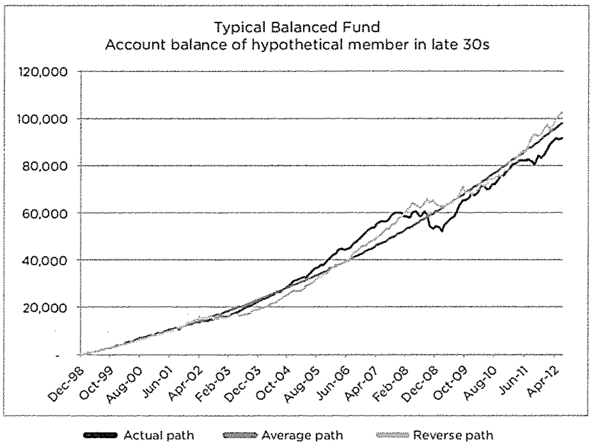
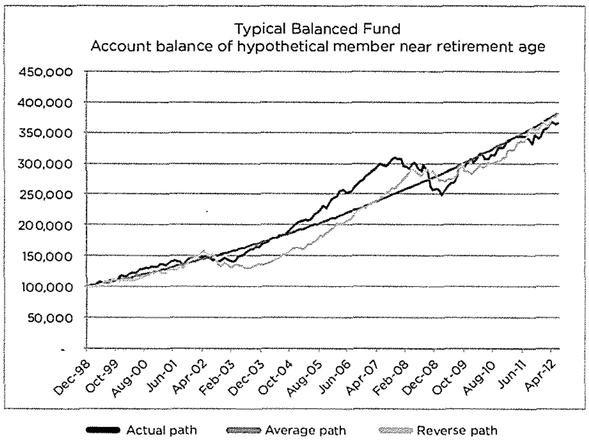


Figure 2 plots three separate accumulation paths for a person who begins their retirement saving at age 25 with a salary of $40,000 and an account balance of zero dollars. Over the 13.5 year accumulation period the salary grows at a rate of 4 per cent per annum such that their income in their late 30s is $68,579. Our hypothetical member contributes at the rate of 9 per cent per annum. The three accumulation paths are as follows: 'Actual path' uses synthetic balanced fund returns as they occurred over the period January 1999 to Jun 2012; 'Reverse path' uses the actual returns in reverse order; and 'Average path' uses the arithmetic mean for the return series for each period.

FIGURE 3: Near retirement



This figure plots three separate accumulation paths for a person who in their early 50s earns a salary of $60,000 with an account balance of $100,000. Over the 13.5 year accumulation period the salary grows at a rate of 4 per cent per annum such that their income near retirement (i.e. mid 60s) is $102,868. Our hypothetical member contributes at the rate of 9 per cent per annum. The three accumulation paths are as follows: 'Actual path' uses synthetic balanced fund returns as they occurred over the period January 1999 to June 2012; 'Reverse path' uses the actual returns in reverse order; and, 'Average path' uses the arithmetic mean for the return for each period.

In Figures 2 and 3 we observe at least two common features. First, terminal wealth at the end of each 13.5 year path differs significantly, in most cases. These differences are shown in wealth and percentage terms in Tables 1 (Late 30s) and 2 (Near retirement). Despite each return path having identical arithmetic means, we can see terminal wealth can be significantly different. This clearly shows the limitations of arithmetic mean returns in measuring the performance of superannuation funds.

Second, we can observe that throughout the 13.5 year accumulation paths, wealth can differ significantly between paths. For example, in Figure 3, between December 2004 and December 2007 the actual and reverse paths are approximately $50,000 apart. Furthermore, in Figure 3, where there is more wealth at stake, the amplitude of the paths is more significant. A risk is that the 'roughness of the investment ride' might induce investors to make decisions that are suboptimal (e.g. to move out of risk assets too early, or too quickly).

TABLE 1: Late 30s

Measure	Actual	Average	Reverse
Arithmetic mean	Identical	-	Identical
Terminal wealth (%)	-6.4%	-	4.6%
Terminal wealth ($)	-$6,311	-	$4,506

Table 1 summarises in percentage and dollar terms the relative outcomes of the three paths shown in Figure 2.

TABLE 2: Near retirement

Measure	Actual	Average	Reverse
Arithmetic mean	Identical	-	Identical
Terminal wealth (%)	-4.2%	-	0.1%
Terminal wealth ($)	-$15,941	-	$284

Table 2 summarises in percentage and dollar terms the relative outcomes of the three paths shown in Figure 3.

But perhaps the most vivid example of the path-dependency of an investor's experience is a comparison of the actual and the reverse paths for each investor:[5]

> **Late 30s** — Actual path is 10.5 per cent lower ($10,817) than the reverse path.

> **Near retirement** — Actual path is 4.3 per cent lower ($16,225) than the reverse path.

We can therefore see that to understand risk in superannuation investing we need to consider realistic accumulation models that incorporate factors like contributions in addition to returns.

Investment policy needs to take account of the accumulation model and the dynamics it introduces. Research suggests that constant asset allocations don't look promising, especially when considered in light of the portfolio size effect and sequencing risk.

Implications for trustees

A number of implications for trustees present themselves from this analysis. First, returns-only measures don't capture wealth dynamics and therefore cannot shed light on the relationship between risk and investment horizon for a superannuation investor. A resolution to the time diversification puzzle thus hinges on an analysis of realistic accumulation models incorporating all relevant variables.

Second, retirement outcomes are highly path dependent. The member gets a single sequence of returns, not smooth 'average' returns. This reality highlights the importance of risk management especially in the latter half of the accumulation phase as the portfolio size effect manifests, and sequencing risk emerges as a serious risk. Investment policy needs to take account of the accumulation model and the dynamics it introduces. Research suggests that constant asset allocations don't look promising, especially when considered in light of the portfolio size effect and sequencing risk. Some researchers have presented evidence to suggest that dynamic strategies may offer assistance (Basu, Byrne and Drew 2011).

Investment governance may need to become dual-focused in order to be comprehensive. In its simplest form, this dual focus would see the following two questions being addressed:

> Are we achieving the member's wealth goals (a wealth-based or money-weighted consideration)?

> Are our managers delivering performance in accordance with expectations and their mandates (generally a time-weighted consideration)? ■

Notes

1. All errors remain the sole responsibility of the authors.
2. Each of these series is the product of 10,000 trials for each of nine investment horizons using a stationary bootstrap simulation method. The standard deviation of annualised returns is calculated for each horizon by computing the mean monthly return for each of the 10,000 return paths, annualising each monthly mean, then taking a standard deviation of the 10,000 annualised means. The standard deviation of cumulative returns is calculated by applying the simulated return path for a given horizon to a starting value of $1. This is repeated for each of the 10,000 paths. The calculation is completed by taking the standard deviation of the 10,000 cumulative returns. Kritzman (1994), in his Figure A (p. 14), shows a 95 per cent confidence interval for annualised returns. This is the confidence interval equivalent of our standard deviation of annualised returns series.
3. Others include Tobin (1965) and Merton (1969).
4. The remaining two streams are the Black-Scholes-Merton Option Pricing Theory stream, beginning with Bodie (1991, 1995), and the behavioural stream. The option pricing theory approach of Bodie (1991, 1995) apparently emerged because of an unrelated breakthrough in economics, not as a result of a specific critique of Samuelson's (1969) work. Only later did others highlight that Bodie's (1995) approach appeared to offer an objective measure of risk in contrast to Samuelson's (1969) normative treatment of risk. Perhaps the most substantial critique of Bodie's (1995) work was that it was conducted in a risk-only framework. Behavioural economists are among the most vocal opponents of any framework that tends to see economics as (hard) science, as opposed to social science. These two visions of economics mix like oil and water. Behavioural economists introduce the richness of humanity to economic problems, often in qualitative terms, whereas 'scientists', of whom Samuelson (1969) was most definitely one, prefer to take approaches characterised by theoretical formality and the rigour of mathematical reasoning, even if it means making simplistic assumptions about human behaviour. In these few sentences, we have briefly outlined both the behaviouralists' principal critique of Samuelson (1969) — the inappropriateness of his underlying assumptions — and our critique of the behavioural stream of literature — the lack of framework, and negative approach to the problem. While the influence of the behaviouralists is limited to providing critiques of the other streams of the literature, they do provide some compelling insights relating to the selection of risk measures.
5. Recall that the period being considered is 13.5 years versus a typical accumulation phase of 40 years. It is possible that over a longer period the divergence could be even more significant.

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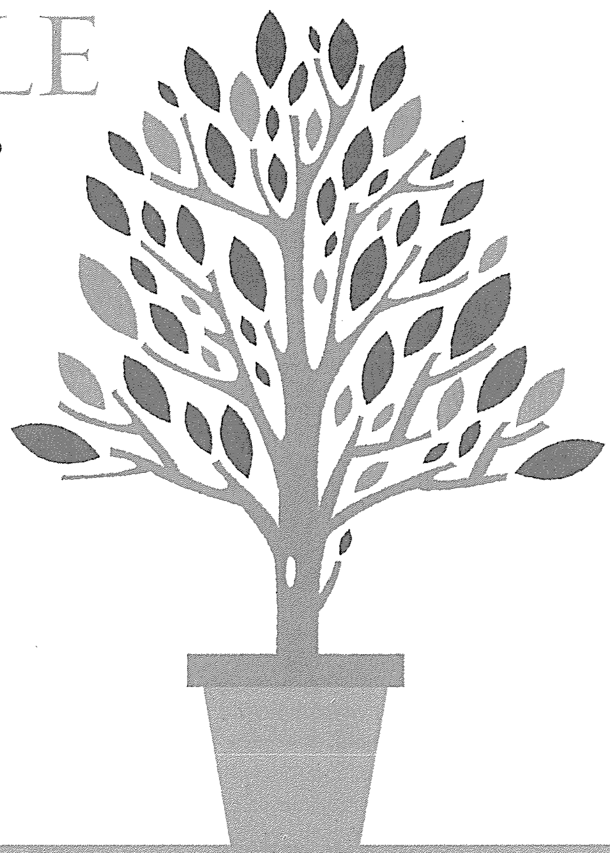
SEQUENCING RISK
A KEY CHALLENGE TO CREATING SUSTAINABLE *retirement income*



RESEARCH REPORT

First published October 2012
Published by: Finsia — Financial Services Institute of Australasia, Level 16, One Margaret Street, Sydney NSW 2000 Australia

ACN 066 027 389 ABN 96 066 027 389

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About the authors
Anup K. Basu, PhD is a Senior Lecturer of Finance at the Queensland University of Technology

Brett Doran is a Research Fellow at Griffith University

Michael E. Drew, PhD SF Fin is Professor of Finance at Griffith University

Suggested citation
Basu, A., B. Doran and M. Drew, 2012, Sequencing Risk: A Key Challenge to Sustainable Retirement Incomes, Finsia (Financial Services Institute of Australasia), Sydney

Availability
This report is available on the Finsia website (www.finsia.com).

Further information and comments
Samuel Bell — Senior Policy Advisor
T > 61 2 9275 7953
E > s.bell@finsia.com

This research was supported by a Finsia Research Grant: 'How important is the order of returns? The impact of sequencing risk on retirement wealth outcomes in Australia' administered by Griffith University. We acknowledge and thank Finsia for their support, particularly Russell Thomas (CEO), Angie Corkhill (Director, Member Relations & Policy), Deidre Grover (Senior Policy Advisor) and members of the Finsia Policy Advisory Council (30 May 2012, Sydney) and Finsia Managed Funds and Superannuation Advisory Group (20 June 2012, Melbourne). We also thank Robert Bianchi, Graham Bornholt, Peter Doran, Evan Reedman, Eduardo Roca, Troy Rieck, Adam Walk and participants at the Griffith University NRIP (Superannuation and Funds Management) Seminar on 'Sequencing risk: the worst returns in their worst order' (4 June 2012, Brisbane) for comments and discussion. Of course, any remaining errors are our responsibility. The views expressed herein are those of the authors and are not necessarily those of Finsia.

FOREWORD

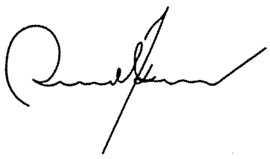
If market risk were not challenging enough for superannuation funds, this important and unique research finds that the sequence in which returns are realised by investors plays a critical role in determining the sustainability of retirement incomes.

Samuel Taylor Coleridge once described poetry as 'the best words in their best order'. Many acclaimed poets throughout history have mastered the craft of arranging or sequencing words in such a way that their poetic quality lingers with us long after reading the final word of a poem. But what happens when one cannot control the arrangement of the words or, for purpose of this study, the sequence of events? Over the past decade, this has been the case for defined contribution (DC) plan members whose retirement savings have experienced a path of events (including the dot.com crash, the subprime crisis, the global financial crisis and the European debt crisis) that arguably could be described as 'the worst returns in their worst order'.[1]

One of the lessons from this extraordinary period of financial history is that the level of retirement savings (and, subsequently, retirement income) is not only a function of the investment returns in every period but also the realised sequence of these returns throughout life.

Sequencing risk becomes more important as the portfolio size increases and is particularly acute during the retirement conversion phase (say, the final 15 years of working life and the first 10 years of retirement).

Using historical and bootstrap simulation from Australian data, this study finds that sequencing risk has a pervasive influence on the sustainability of retirement income and this risk is particularly acute around the period in which retirement savings are at their peak.



RUSSELL THOMAS F Fin
CEO and Managing Director
Finsia

1. As shown in the historical simulation section of this study, some 40-year investment horizons over the past century (particularly those ending in the 1970s) were acutely affected by sequence of returns risk.

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Sequencing risk adds to the range of important risks faced by members of defined contribution superannuation funds in Australia. With increasing numbers of baby boomers entering the 20–25 year conversion phase from retirement savings into retirement income, the sequence of returns risk is a current and significant challenge both for fund members and policy makers. Many investors are unaware that the sustainability of their retirement income largely is determined not by the average return of their investments, but the realised sequence of those returns.

Australia's retirement saving system, known as superannuation, is dominated by defined contribution (DC) plans. A recent study by Towers Watson (2011) reported that in 2010, around 80 per cent of all pension assets in Australia were held by DC plans (compared with 57 per cent in the United States of America (US), 40 per cent in the United Kingdom (UK) and only 2 per cent in Japan).[2] This defining feature of the Australian system has led to much debate about the risks faced by DC plan members and the systemic and idiosyncratic features of the system. Two key reports recently commissioned by the Australian Government, the Cooper[3] and Henry[4] reviews, make important contributions to the debate highlighting the need for further product innovation to assist members with mitigating investment, longevity and inflation risk.[5]

Sequencing risk is a further risk for DC plans, which is sometimes hidden from direct view and this research seeks to frame this risk more formally for all stakeholders in superannuation, particularly fund members. The paper highlights that sequencing risk is a pervasive factor, which is constantly encountered by DC plan members and becomes particularly acute during the critical retirement conversion phase (that is, late accumulation and early decumulation).

The first of the baby boomer cohort turned 65 years of age in 2011. The final decade of their investing journey included the aftermath of the dot.com collapse, the 9/11 terrorist attacks, the invasions of Iraq, the subprime mortgage crisis, the global financial crisis, Madoff Ponzi scandal, the European debt crisis and the US downgrade to AA+. This highlights the extent to which the sequence or ordering of events plays a critical role in the sustainability (or otherwise) of retirement savings and, ultimately, retirement income.

The key finding of this study is that the average of accumulated investment returns is not necessarily the key driver of retirement outcomes. Rather, it is the sequence of these returns that is paramount. If someone encounters the sequence of returns observed in the first decade of the twenty-first century quite early in their career, say in their twenties, they have time to recover from these relatively low returns over the next four decades of their working life. However, for someone who is 60 years of age and whose retirement outcomes are largely driven by investment returns, experiencing this sequence of returns over the final decade of their working life leads to a vastly different outcome. Unlike the younger investor, the 60-year-old does not have the time to recover from these investment losses through gains made on future contributions, resulting in a fall in the adequacy of retirement savings and heightened longevity risk.[6]

In recent years, a variety of definitions have been developed to capture the essence of sequencing risk. While all definitions face limitations, it is important to note the context in which the definition is formulated (particularly those originating from countries where defined benefit (DB) plans dominate).

Some of the key definitions of sequencing risk in recent years have included:

> 'Sequence of returns risk is an investment risk that only affects investors who are actively drawing income from their investment portfolios' (Eszes 2010). This definition limits sequencing risk to the decumulation phase and does not consider the risk during the accumulation period (largely because of a DB-based system).

2. It is important to note that the current state of play is nothing new for Australia, with DC plans holding 78 per cent of total pension assets in 1999. The proportion of pension assets held by DC plans was: US (44 per cent); UK (5 per cent); and Japan (negligible), (Towers Watson 2011).

3. *Australia's Super System Review, Final Report* (the Cooper Review) is available at: www.supersystemreview.gov.au/. Note from the report, the statement that 'a number of industry participants have turned their minds to the challenge of product innovation in the post retirement phase. The broad theme of these developments has been to explore ways to better manage the key risks (investment, longevity and inflation) to which people are directly exposed in the account-based pension framework'.

4. These themes, particularly related to issues of longevity risk, are supported by *Australia's future tax system: report to the Treasurer* (the Henry Review) available at: http://taxreview.treasury.gov.au/content/Content.aspx?doc=html/home.htm. The report notes 'the current retirement income system does not provide the products that would allow a person to manage longevity risk. This is a structural weakness'.

5. For an international perspective, see the Organisation for Economic Co-operation and Development (OECD) report by Antolin et al. 2010.

6. There is an important body of literature that considers the value of transferring risk from a corporate defined benefit (DB) plan to a DC plan. A key contribution by Milevsky (2007) examined companies which were undergoing a transition from DB to DC plans at an average of one company a month for the period 2001 through to mid-2007. Milevsky (2007) found that these companies experienced an average risk-adjusted abnormal return of around four per cent during the 10 trading days before and after the announcement of this information to the market.

> 'Investors in any phase are vulnerable to the market's random gyrations, but investors in the distribution phase are even more sensitive to unfortunate timing. They may retire at a favorable time in the market or during a highly unfavorable period' (Jones 2007). Again, this definition predominantly focuses on the decumulation or distribution phase; however, the vulnerability to sequencing risk 'in any phase' is acknowledged.

> 'Sequencing risk has to do with the (bad) risk of needing to pull money out of a portfolio during a particularly poor performance year and the (good) risk of being able to add money during a down year' (Minor 2011). This definition is particularly interesting as it incorporates both 'bad' and 'good' elements of sequencing risk. While applicable across one's investing life, the dynamic nature of the risk needs further exploration.

> 'What's more important to your clients, rate of return or order of return? The gut reaction of nearly every financial adviser is rate of return. But for your clients in the second half of their financial lives, I argue that order of returns (also known as the sequence of returns) is every bit as important as rate, and is potentially the biggest retirement risk of which your clients are unaware' (Neuman 2011). This definition highlights one of the key ideas in the sequencing risk debate. Investors would prefer the lowest rates of return when they have the smallest account balances (the early years). As portfolio balances grow larger and retirement comes closer, larger returns are desired (Neuman 2011).

The worst returns in their worst order

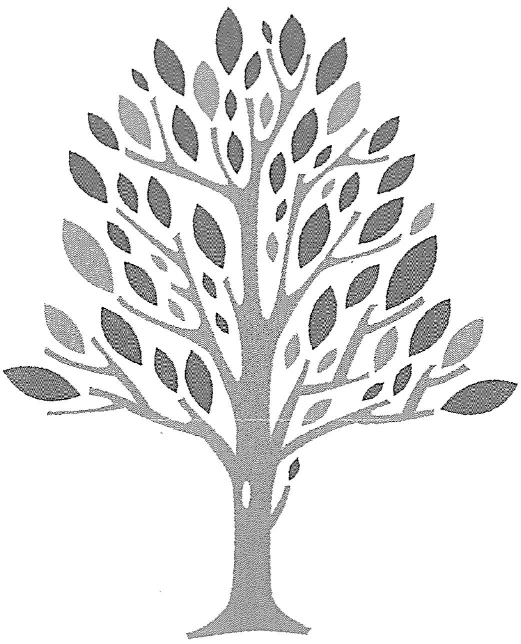
For the purposes of the study, the working definition of sequencing risk is the *worst returns in their worst order*. It is suggested that in a DC framework, sequencing risk emerges right from the point when the second contribution is made to the member's account. As portfolio size grows with multiple contributions and the accumulation of returns, the risk becomes more acute over time. The growth in portfolio size is driven by multiple cash inflows to the portfolio both in terms of contributions and investment returns, with the latter usually accounting for an increasingly larger proportion of the portfolio balance over time. As such, sequencing risk is prevalent both in the accumulation and decumulation phases of a member's investing life and, by definition, occurs well before a DC plan member's retirement date.

In short, sequencing risk is the risk of experiencing returns in an unfavourable order during periods facing changes in invested capital, either through contributions or distributions. The unfavourable order is observed when large negative returns are experienced during the period with the greatest portfolio balance (that is, the worst returns in their worst order).

As investigated empirically, the key factors influencing sequencing risk are: the size of the contributions (or withdrawals); the growth of the contributions (or withdrawals) through time; the timing of contributions (or withdrawals); the portfolio balance and the return volatility. Given Australia's DC plan heritage, this research focuses on the accumulation phase (that is, up to the retirement date) to highlight the emergence of sequencing risk from a DC plan member's perspective, not simply considering the issue at the decumulation/distribution phase (which takes more of a DB plan perspective).

For DC plan members, sequencing risk grows with the portfolio balance — as the portfolio (or retirement nest egg) increases in size, the variation that can occur in the dollar value of this portfolio also increases. This idea has been described by Basu and Drew (2009a) as the 'portfolio size effect'.

The key determinant of retirement outcomes in DC plans is the interplay between portfolio size effect (what you do when the largest amount of your money is at risk matters; that is, during the retirement conversion years) and the related problem of sequencing risk. In short, poor returns in a bear market may not be anywhere near as important as the timing of the loss, especially over the conversion phase.



1. WHAT DRIVES SEQUENCING RISK?

Investors walk a constant tightrope in seeking to take a prudent amount of risk at every stage of their working lives. Too little risk and one will fall short of the promise of endless summers; too much risk can deplete retirement savings to a point which it may never recover (Doran, Drew and Walk 2012). There are a limited number of approaches to investigating the drivers of sequencing risk.[7] These methods invoke the ceteris paribus assumption (that is, assuming all else is equal) to consider the impact of sequencing risk on retirement savings. This study uses both historical simulation (that is, actual 40-year historical investment returns paths from 1900 to 2011) and a bootstrap approach (that is, a sampling approach that allows sequencing risk to be considered for possible future paths that are simulated from the empirical distribution of returns) to investigate sequencing risk from the perspective of a DC plan member in Australia.

Before commencing an empirical analysis of sequencing risk, the data and methodological approach of the study need to be considered. It is known that contributions are a key driver in determining retirement outcomes. In order to consider these outcomes through the prism of sequencing risk, a simple, hypothetical DC plan member who was born on 1 January 1987 was developed. The member commenced their working life this year, at 25 years of age (1 January 2012) with a targeted retirement at 65 years of age (1 January 2052). Table 1 outlines the key assumptions attributed to the hypothetical DC plan member, with figure 1 illustrating their assumed nominal cumulative contributions over the 40-year accumulation period.[8, 9]

Table 1 outlines the key assumptions attributed to the hypothetical DC plan member, with figure 1 illustrating her assumed nominal cumulative contributions over the 40-year accumulation period.[9,10]

It is important to note that, throughout this study, the analysis commenced as at 1 January 2012 and considered the impact of various return paths (historical and simulated) over the hypothetical DC plan member's accumulation phase. Nominal contributions (and nominal returns, as discussed below) are used to consider the impact of different sequencing on retirement outcomes. These simplifying, present-day assumptions regarding starting salary, salary growth rates, contribution rates and retirement age, in concert with nominal returns, allow for the variable of interest — accumulated savings in a DC plan — to be a function of the sequence of returns.

The data used in this study comes from the Dimson Marsh Staunton (DMS) (2002) database and represents nominal annual returns for 112 years from 1900 to 2011.[10] This long-run data allows the study to examine a large number

Table 1: Key assumptions

VARIABLE	ASSUMPTION
Starting balance	$0
Starting salary	$41,552*
Salary growth rate	4% p.a.
Contribution rate	9% p.a.
Starting age	25 years**
Retirement age	65 years

* Average MyCareer minimum starting salary across all sectors as at end-April 2012.

** First contribution made at end of first year (that is, 1 January 2013), final at end of final year (that is, 1 January 2052), contributions experience 40 years of returns though investment horizon is 41 years.

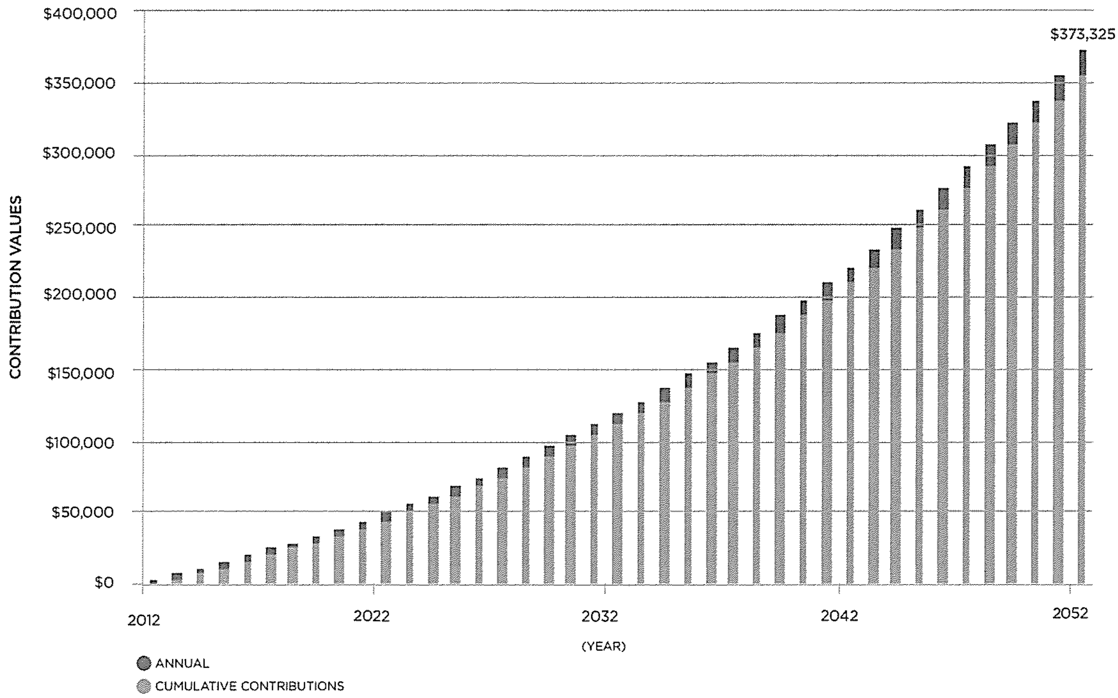
7. See Milevsky and Abaimova (2008); Milevsky (2009); and Milevsky and Macqueen (2010).

8. The main body of the study considers nominal returns and contributions to investigate sequencing risk. This is because returns being earned by DC plan members are nominal in nature (and, as accumulated returns, coupons and dividends are paid in nominal terms). The use of nominal returns has precedent in the broader pensions literature (see, for example, Hickman et al. 2001; Guo and Darnell 2005; Basu and Drew 2009a; and Basu, Byrne and Drew 2011) and retirement wealth ratios (RWRs) are reported that allow future nominal retirement outcomes to be based on the final nominal salary of our hypothetical DC plan member. However, it is acknowledged that using real returns and contributions would provide a useful confirmatory analysis through which to consider the impact of sequencing risk. Appendix 3 undertakes an identical methodology to that reported in the main body of the study (but using real returns and contributions), corroborating the key results and providing further practical insights into sequencing risk from an inflation-adjusted perspective.

9. It is acknowledged that these are simplifying assumptions. There are a number of possible salary growth trajectories that could have been considered (for example, Byrne et al. 2006 show a humped profile for men and women in the UK) associated with gender and career breaks (see Basu and Drew 2009b), the casualisation of the workforce (Pocock 2003), housing and superannuation (Davis 2007), and the role of human capital (Merton 1969). The challenge with all such modelling is that a trade-off between 'real-world features' and building a simple model that allows us to consider the interplay between terminal wealth (dependent, or y variable) and sequencing risk (independent, or x variable) is faced. For example, it is known that many people 'back-load' voluntary contributions into their DC plan late in their career. As such, a constant increase that possibly underestimates salary growth early in the career, but attempts to incorporate potential back-loading of contributions later in the career, is allowed. It is noted that further research in this area is an important next step in the development of DC plan literature.

10. The DMS database lists real returns for the period 1900 to 2011 (n = 112). Australian stocks, bonds and bills are listed in AUD. The real returns for US stocks and bonds are reported in USD and converted into AUD returns using the exchange rate return provided by DMS. All returns are converted into nominal returns as the study uses nominal values for salary growth. The database is available commercially from Morningstar.

Figure 1: Cumulative contributions of a hypothetical DC plan member using assumptions from table 1



(n = 73) of overlapping (1900–1939, 1901–1940 ... 1972–2011) 40-year paths through to 2011 in the historical simulation and provides a rich source of data for the bootstrap approach.

In order to 'generate' investment returns, some assumptions regarding asset allocation were made. The vast majority of Australians (that is, around 80 per cent) are enrolled in the default option of their superannuation fund, and that these predominantly target risk in nature, with around two-thirds allocated to growth assets (Towers Watson 2012). The growth-oriented nature of default options in Australia is confirmed by the Australian Prudential and Regulation Authority (APRA) (2012) asset allocation data on the default investment strategy of Australian superannuation funds (as at 30 June 2011).

A common problem facing DC plan researchers internationally is how to convert the actual default asset allocation (which includes not only stocks, bonds and bills, but also unlisted property, private equity, infrastructure, alternatives and more) to develop a proxy asset allocation that allows long-run analysis.[11]

The methodological approach of Basu and Drew (2009a); and Basu, Bryne and Drew (2011) is followed and the following assumptions regarding the default asset allocation strategy employed in this study are made:

> 'Other assets' are assumed to be made up of growth assets. The 13% is divided into 'Australian shares' and 'international shares'; seven per cent and six per cent, respectively.

> 'Listed property' and 'unlisted property' is assumed to have similar properties to fixed interest assets. 'Australian fixed interest' is allocated six per cent of the combined 10%, while 'international fixed interest' is allocated the remaining four per cent.

> 'International shares' and 'international fixed interest' use US equities and bonds (converted into AUD), respectively, as a proxy for international investments in the default strategy. Figure 3 illustrates the default strategy used in this study.[12]

Given long-run data restrictions, a five-asset portfolio that is target risk in nature and rebalanced annually is constructed. No taxes, fees or transaction costs are assumed in this analysis.[13] As with current practice, the default

11. For a more detailed discussion on this procedure see Basu and Drew (2010).

12. It is important to note that *very basic proxies* for the default position of Australian superannuation funds as they exist today are used. Given that the research motivation is to consider the sequence of returns risk over long horizons in Australia, long-run historical data (with an annual frequency) is used. Therefore, as with other papers considering the potential long horizon performance of defined contribution plans, this study sacrifices the opportunity to select more precise proxies for various asset classes (for instance, it would perhaps be advantageous to use a monthly MSCI World Index ex Australia hedged in AUD as a proxy for international shares. The trade-off is that this index was only launched on 31 December 1969, compared with the 1900 start date for the DMS data).

13. It is acknowledged that the tax treatment of contributions and investment earnings, and the impact of costs, are important issues worthy of future research consideration. It is noted that taxes are levied on a nominal basis, further supporting the use of nominal contributions and returns in this study.

Figure 2: Asset allocation of the default investment strategy in Australia

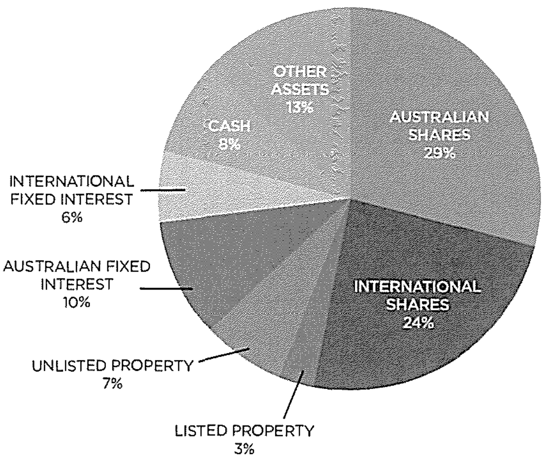
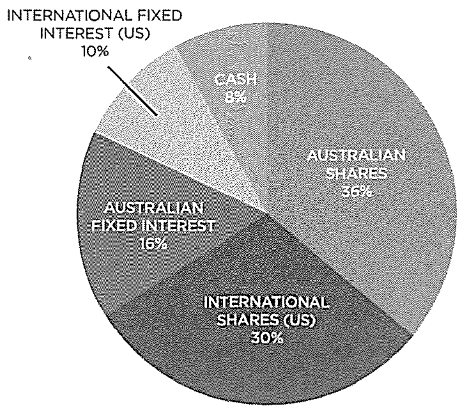


Figure 3: Asset allocation of the default strategy used in this study



growth assets (66/26/8 stocks/bonds/bills allocation, or 66/34 growth/income), reflecting the growth-oriented asset allocation that is applied in the DC plans of the vast majority of Australians. Table 2 provides summary statistics for the investment returns from such a default strategy from 1900 to 2011.

Table 2: Summary statistics for the default strategy (1900-2011)

VARIABLE	ASSUMPTION
Mean	10%
Standard deviation	11%

As discussed previously, when the proportion of retirement savings dwarfs future expected superannuation contributions, the ordering or sequencing of returns becomes a key driver of outcomes for DC plan members. By way of simple example, taking the hypothetical member who commenced in the workforce on 1 January 2012, recall that her first contribution to superannuation will be made on 1 January 2013. It is assumed that the most recent 40-year return path (1972–2011) repeats again for 2013–2052, when the member retires at 65 years of age. Now, imply reverse the order of returns and create a new 40-year return path for the member (2011–1972). It is important to note that, as shown in Table 3, the two return paths have identical return distributions (all four moments are identical) as they depict the same returns, just in a different order — reversed to be precise (exposing the superannuation portfolio to a specified amount of risk). Table 3 also shows the most extreme sequencing paths for 1972 to 2011 in which the DC plan member experiences returns from worst to best (ascending order) and best to worst (descending order), respectively.

Merely reversing the order in which returns are experienced, 2011–1972 as opposed to 1972–2011, yields two very different accumulation outcomes: $4.0 million (1972–2011) and $5.4 million (2011–1972), a material difference of $1.4 million or around 35 per cent. Interestingly, this difference of $1.4 million is around four times the total (or lifetime) nominal contributions made by the member to 2052 (of around $373,000). Figure 4 gives a glimpse of the potential impact of this largely hidden, but pervasive factor, known as sequencing risk.

A DC plan accumulation path can be thought of as being broken up into multiple superannuation contributions, which track their own return path through time. The first contribution experiences every return the portfolio experiences. Subsequent contributions are not affected by previous returns, but only by future returns. With this framework, it can be seen that future returns affect a greater number of contributions. Hence, when the size of the superannuation nest egg exceeds future expected contributions, the returns occurring late in the accumulation phase (and early in the decumulation or distribution phase) have the largest impact.

Although much of the emphasis in the debate about sequencing risk casts it as a negative risk, like standard deviation it can also have a positive impact. Intuitively, the two extremities of sequencing risk — downside and upside — or 'bad' and 'good' risk, can be observed. Downside (upside) sequencing risk arises when the most negative (positive) returns are being experienced and when the most contribution paths (and thus the largest amount of money) are being affected by the return. Ordering the returns from largest (smallest) to smallest (largest) provides the extreme downside (upside) of a path of returns. Figure 5 illustrates these extreme outcomes

Table 3: Annual returns for the default strategy for the 40-year period from 1972 to 2011

	ACTUAL (1972-2011)	REVERSED (2011-1972)	BEST (ASCENDING)	WORST (DESCENDING)
	14%	3%	-22%	42%
	-22%	3%	-12%	40%
	-12%	10%	-10%	35%
	35%	-10%	-10%	32%
	20%	6%	-8%	31%
	7%	11%	-3%	30%
	14%	15%	-2%	28%
	27%	15%	-2%	27%
	23%	4%	3%	26%
	-3%	-8%	3%	25%
	17%	5%	4%	23%
	40%	11%	5%	20%
	9%	10%	6%	18%
	42%	18%	7%	17%
	32%	30%	8%	15%
	-2%	11%	9%	15%
	8%	28%	10%	14%
	25%	-10%	10%	14%
	-2%	26%	10%	11%
	31%	10%	11%	11%
	10%	31%	11%	11%
	26%	-2%	11%	10%
	-10%	25%	14%	10%
	28%	8%	14%	10%
	11%	-2%	15%	9%
	30%	32%	15%	8%
	18%	42%	17%	7%
	10%	9%	18%	6%
	11%	40%	20%	5%
	5%	17%	23%	4%
	-8%	-3%	25%	3%
	4%	23%	26%	3%
	15%	27%	27%	-2%
	15%	14%	28%	-2%
	11%	7%	30%	-3%
	6%	20%	31%	-8%
	-10%	35%	32%	-10%
	10%	-12%	35%	-10%
	3%	-22%	40%	-12%
	3%	14%	42%	-22%
Mean	**12%**	**12%**	**12%**	**15%**
Standard deviation	**15%**	**15%**	**15%**	**15%**
Skewness	**-0.04**	**-0.04**	**-0.04**	**-0.04**
Excess kurtosis	**-0.28**	**-0.28**	**-0.28**	**-0.28**
Terminal wealth	**$4.0m**	**$5.4m**	**$17.4m**	**$1.4m**

using the same historical path (1972–2011) reordered for the hypothetical member. Figure 5 illustrates the extreme outcomes for sequencing risk for a single historical path from 1972 to 2011. The difference between the two paths is around $17.4 million or 46 times total lifetime contributions. The upside sequencing risk path has actually beaten the downside sequencing risk path by a factor of 12 times. While it is conceded that these outcomes are unrealistic (as extreme scenarios are), they provide another insight into the potential impact of sequencing risk on a portfolio. Perhaps the key lesson to be learned is that when investment returns and performance results for members of DC plans focusing on the four moments of the distribution (and typically, the emphasis is on the first moment, the average return) are presented, it is important to understand that the historical shape of the distribution of investment returns, not its order, is being described.

Figure 4: Wealth accumulation paths for two return paths: (1972–2011) and the reverse (2011–1972)

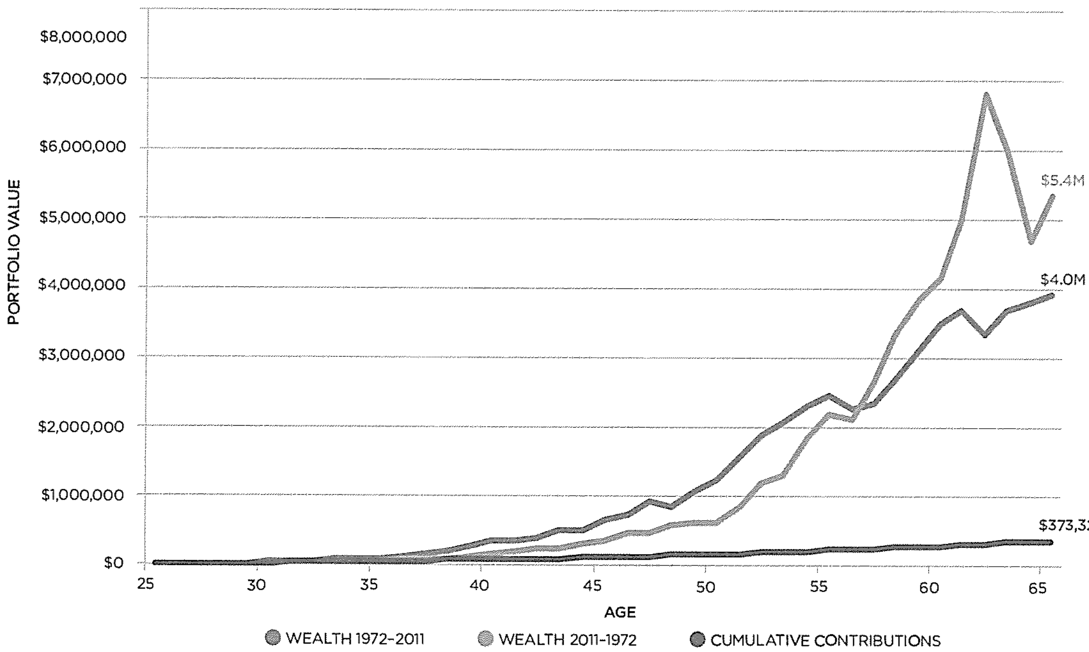
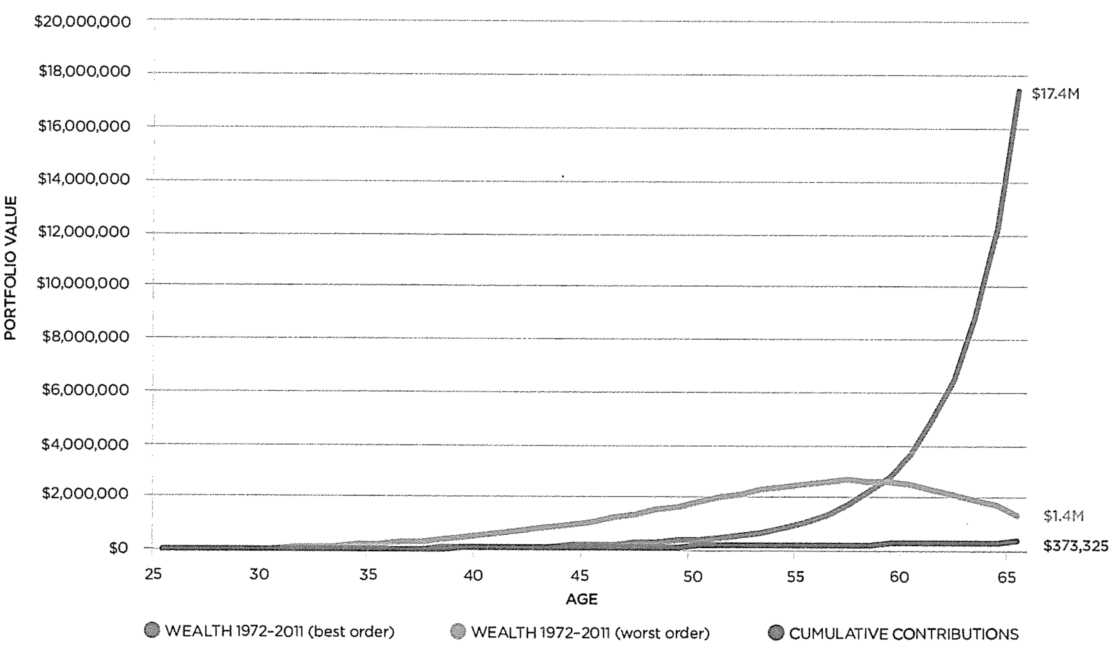


Figure 5: Wealth accumulation paths for the best (smallest to largest) and worst (largest to smallest) ordered returns of the default strategy from 1972 to 2011



2. WHEN IS SEQUENCING RISK A PROBLEM?

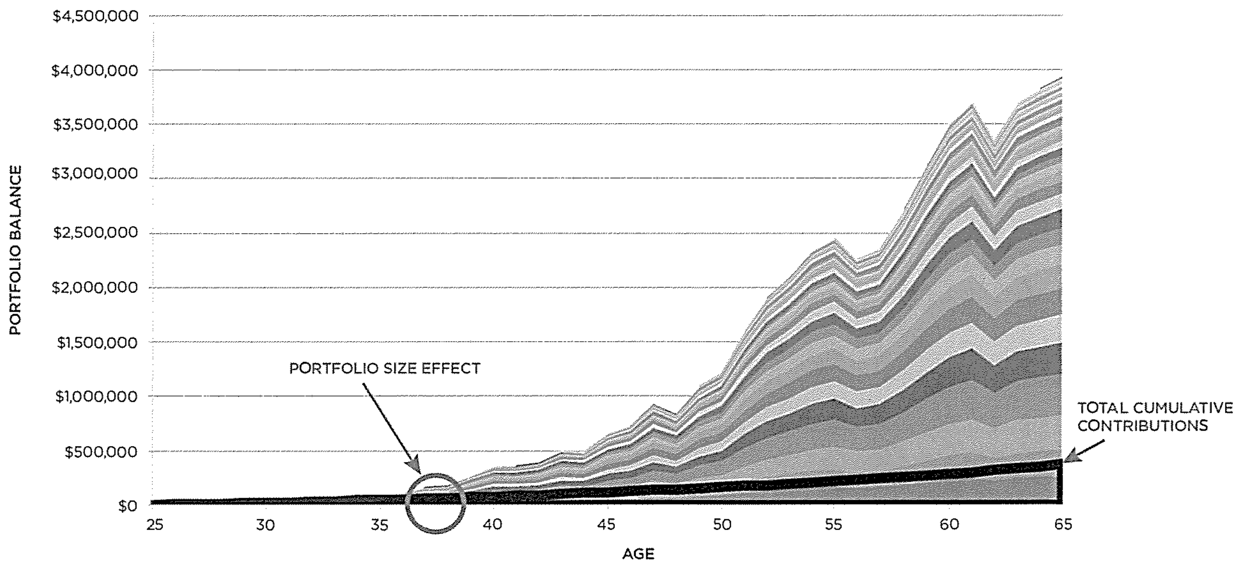
Sequencing risk becomes more acute as the size of the DC portfolio increases and retirement outcomes are more reliant on investment returns. The risk is also apparent in all portfolios which are experiencing capital changes via either contributions or distributions.

Basu and Drew (2009a) introduced the notion of the 'portfolio size effect' to the literature. They found that the investment return attributed to DC plans towards the end of the accumulation (and early decumulation) period is the main driver of terminal wealth in a DC plan. In practical terms, the largest losses (and gains) are made when the largest amount of retirement savings is at risk. The intersection between the portfolio size effect and sequencing risk leads to some interesting insights: see figure 6.

Returning to the hypothetical member, starting their working life in 2012 at age 25 and experiencing the identical return path that occurred from 1972 to 2011, figure 6 illustrates each contribution's growth through time from the 1972–2011 return path (identical to figure 4, a final accumulated balance at age 65 of $4.0 million, with contributions of $373,325). Recall that the simplifying assumption was made that there are 41 annual contributions made by the member from 2013 to 2052 (final contribution does not experience a return) . The teal circle in figure 6 indicates the point at which the cumulative contributions (black line) are half (or 50 per cent) of the total portfolio size. In the case of the hypothetical member this occurs at 37 years of age.

The analysis provides further insight into the working definition of sequencing risk — *the worst returns in their worst order*. Using the 73 historical returns paths as a guide (1900–1939, 1901–1940 ... 1972–2011) different return paths are applied to the 25-year-old member commencing in thier DC plan in 2012. Figure 7 illustrates every 40-year path's cumulative contribution divided by accumulated retirement savings (or total portfolio size to date) across the entire accumulation period. It is important to note the significance of the colour coding in figure 7. The gold section represents all 40-year paths, which end from 1939 to 1970 (n = 32) while the teal section represents all 40-year paths, which end from 1971 to 2011 (n = 41). This colour coding is consistent throughout this study.[14]

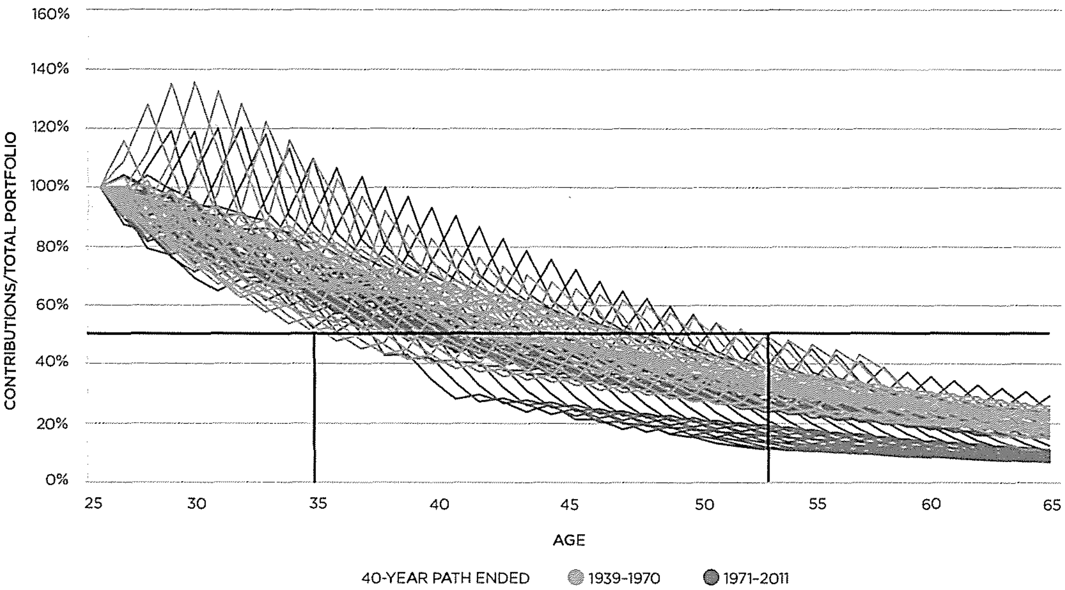
Figure 6: The default strategy's growth through time for the 40-year accumulation period from 1972 to 2011 — each colour represents a different contribution path through time



14. Some of the paths in figure 7 illustrate contributions totalling greater than 100 per cent of the portfolio. This has occurred due to paths experiencing large or multiple negative returns in the early years of accumulation (such as those just prior to the 1974 crash) and thus their investment earnings are negative and have reduced total portfolio sizes below that of the cumulated contributions to date.

Figure 7 highlights the point at which the 50 per cent contribution-to-total portfolio size point is reached and, as expected, this is dependent upon the order of the returns. For all of the 40-year accumulation paths from 1900 to 2011 (as applied to the hypothetical member), the range of outcomes is between 34 and 54 years of age (the 9th and 29th years of accumulation, respectively). It can be seen that, beyond this point, the acceleration towards investment returns accounts for an increasingly larger proportion of the portfolio balance. While acknowledging the distribution of particular outcomes, one important point to note from figure 7 is that in the final years of the accumulation phase (say, the last 10 from age 56), a rule of thumb can be applied such that contributions only account for about one-fifth (or 20 per cent) of the total DC plan size.[15] The findings suggest that there is something similar to the Pareto principle[16] ('the vital few and trivial many') at play with sequencing risk; that is, late in the accumulation phase around 80 per cent of the member's final balance is attributable to returns, and 20 per cent to contributions.[17] This provides further nuance to our understanding of sequencing risk, *the worst* returns in their worst order. The finding suggests that even muted levels of bad volatility, occurring at the worst time, can have a significant impact on members' retirement savings. Indeed, it is not necessarily the magnitude of the negative return that matters, but its timing.

Figure 7: Total cumulative contributions as a percentage of total portfolio balance for all 40-year accumulation paths from 1900 to 2011 using the default strategy's annual returns (n=73)



15. This rule of thumb is supported by the inflation-adjusted analysis presented in Appendix 3, where it is a 40 per cent (contributions), 60 per cent (returns) general rule.

16. The term 'the Pareto principle' and the associated quote 'the vital few and the trivial many' has been attributed to Joseph M. Juran (1904-2008) based on the work of Vilfredo Pareto, for a discussion see: www.juran.com/index.html

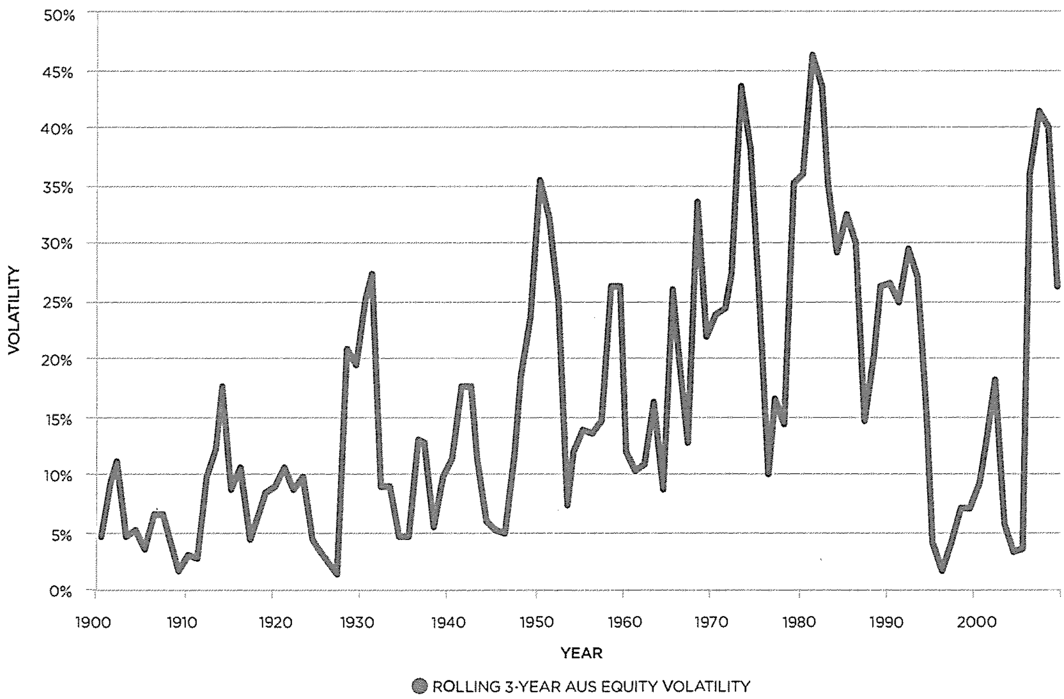
17. The mean (contribution/portfolio balance) 10 years from retirement for all 40-year accumulation paths is 21 per cent while the minimum and maximum are eight per cent and 44 per cent, respectively.

3. WHERE IS SEQUENCING RISK GOING?

The case has been made that sequencing risk becomes more acute closer to retirement when the portfolio size grows exponentially with returns dwarfing contributions. Now the volatility of a DC plan's balance in percentage terms needs to be brought to the fore. In dollar terms, volatility on a small portfolio balance does not impact the dollar value as severely as the same volatility on a large portfolio balance. Using rolling three-year volatility from Australian equities as a guide, it can be seen that the volatility of returns has been increasing over the past 112 years. Intuitively, this makes sense as a number of events that have caused major disruptions to financial markets have occured during the past quarter century: from the 1987 stock market crash through to the global financial crisis. In this section, the impact of a higher standard deviation of returns in the later years of the working life is explored, finding that this results in a higher variation in retirement wealth outcomes for DC plan members.

The rolling volatility results shown in figure 8 confirm that the standard deviation of returns for Australian equities has been on the rise over the past century. To illustrate the distributional characteristics of the data from 1900 to 2011 for the default strategy, a histogram can be constructed. However, a standard histogram provides a limited insight into the time-varying characteristics of the return volatility. Figure 9 depicts a histogram of the annual returns from the default strategy (66/26/8 stocks/bonds/bills allocation) for the period 1900–2011. Note that the colour coding used in this histogram is the same as that used in the previous section; the gold represents returns which affect the 40-year accumulation paths ending 1939–1970, while the teal represents the returns which affect the 40-year accumulation paths ending 1971–2011. The blue is included in this diagram as there are some return paths which overlap into both subsets.

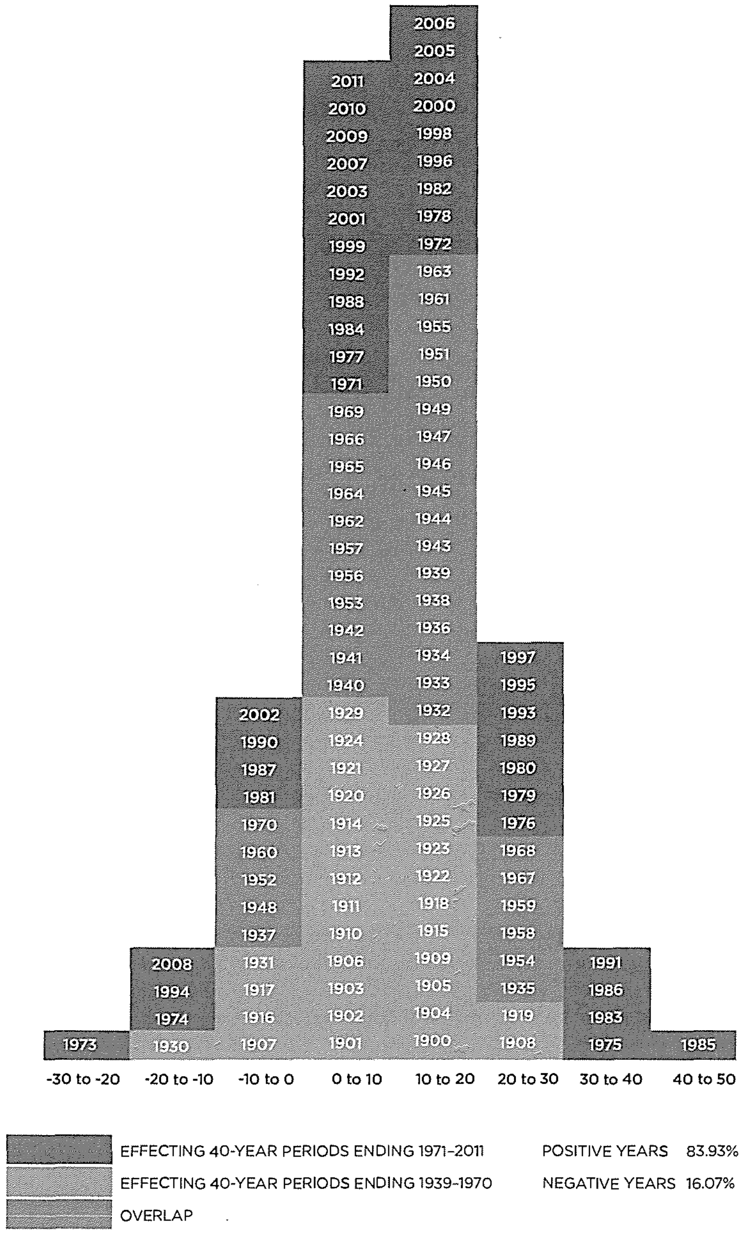
Figure 8: Rolling three-year Australian equity volatility from 1900 to 2011



The histogram in figure 9 shows that the returns from the latter part of the sample period are more dispersed than those encountered earlier in the sample.[18] This particularly is evident in the tails of the distribution, such as the -30 to -20 per cent bucket (1973), the +30 to +40 per cent bucket (1975, 1983, 1986 and 1991) and the +40 to +50 per cent bucket (1985).

With the confirmation that historical volatility is increasing through time, the potential impact this may have on the hypothetical DC plan member can be seen. Figure 10 shows every historical 40-year return path that is available from the sample (with the first being 1900–1939 and the last being 1972–2011). These respective sequences or paths of returns are applied to the hypothetical member commencing in the DC plan in 2012.

Figure 9: Histogram of the default strategy's annual returns (1900–2011)



18. It is important to note that the distribution of real returns has greater negative skewness and fatter tails, making the problem of sequencing risk potentially more pronounced (see appendix 3).

The volatility of returns, combined with their historical order, is a driving force for the distribution of retirement outcomes for the hypothetical member. The results show a clear increase in the range of possible outcomes over time. If the hypothetical member were to experience 40-year accumulation paths similar to that from 1939 to 1970 (gold), this would result in a distribution of final account balances of between $1.9 million and $3.2 million — a comparably narrow range of around $1.3 million. However, if the hypothetical member were to experience paths of returns similar to that for periods ending 1971–2011 (teal) in the future, the member would have a much wider distribution of retirement outcomes, albeit with a larger average balance. These outcomes range from $1.4 million (using the return path concluding in 1974) to a maximum of $6.7 million (the return path concluding in 2000) — a range of around $5.3 million.

The interplay between the distributional characteristics of the returns and the sequence in which they are experienced are important considerations for DC plan members. However, it would be unrealistic to conclude that the distributional characteristics of the final account balances presented in figure 10 are driven purely by sequencing risk. Some of the historical paths used in the analysis have superior average returns and thus represent a better path in general. To quantify the effect that sequencing risk has on the individual paths, their returns using a form of heat map are considered. Figure 11 presents the return paths experienced by each of the 40-year accumulation paths. The colours in the heat map are coded as follows:

> annual returns below the long-term average annual return are light blue;

> annual returns above the long-term average annual return are teal; and

> extreme returns are red (negative) and gold (positive) (extreme returns are classified as being beyond two standard deviations from the average return).

Figure 10: Every 40-year accumulation path from 1900 to 2011 using the default strategy's annual returns (n=73)

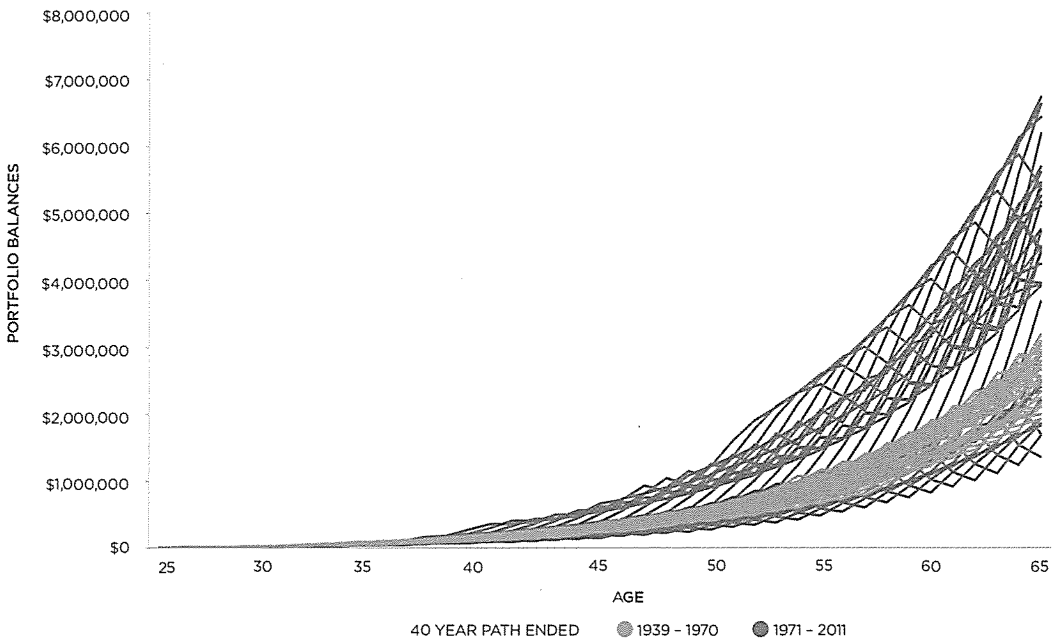
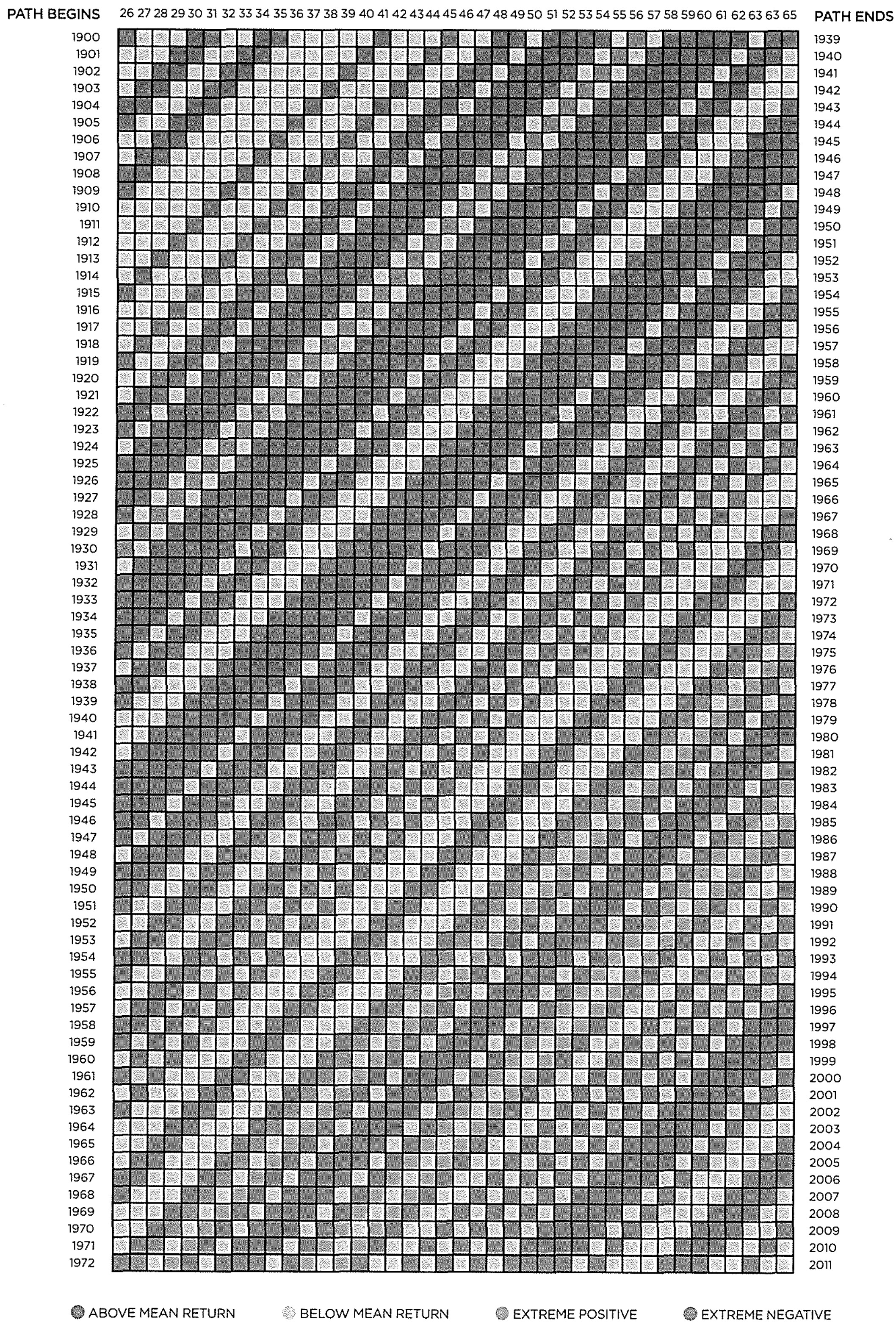


Figure 11: Heat map of the default strategy's annual returns for every 40-year accumulation path from 1900 to 2011 (n=73)



Perhaps the most striking feature of the heat map is just how different the order of the returns has been throughout history. Examining an extract from figure 11, figure 12 illustrates the best (path ending 2000) and worst (path ending 1974) paths.

Figure 12: Best and worst 40-year accumulation paths (figure 11 extract)

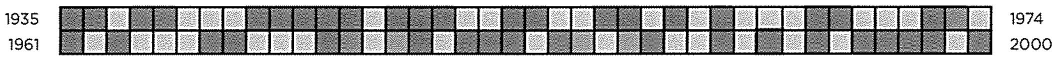
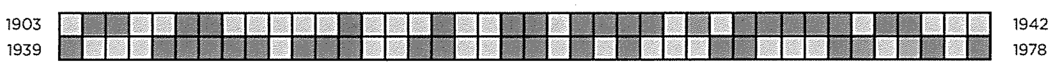


Figure 12 shows a large group of positive returns (gold) for the 2000 path, the best performing path ($6.7 million). The large negative (red) returns that occurred late in the path ending 1974 illustrate why this is the worst performing path ($1.4 million). The best performing path also faced similar large negative returns; however, this was experienced much earlier in the accumulation path.

Looking at another two paths from figure 11, figure 13 illustrates two paths which had similar outcomes — paths ending 1942 and 1978.

Figure 13: 1942 and 1978 40-year accumulation paths (figure 11 extract)



The two paths ending 1942 and 1978 in figure 13, both had a final portfolio balance of $1.9 million (with a difference of only $506). These similar results occurred despite the fact that there was a markedly different order of the returns during the final decade. However, if one looks at each path's arithmetic and geometric returns (listed in table 4), some interesting results are found.

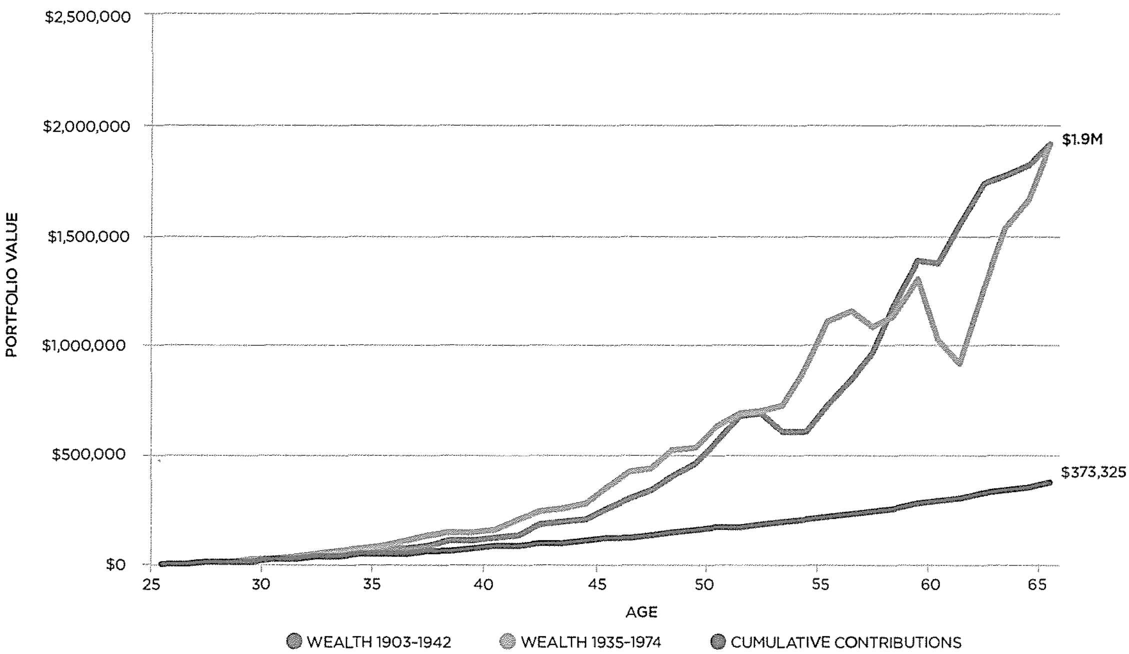
Table 4: Arithmetic and geometric returns for 40-year accumulation paths from figure 13 (40-year accumulation paths ending 1942 and 1978)

	1942	1978
Arithmetic return per annum	8.69%	9.40%
Geometric return per annum	8.36%	8.69%
Terminal wealth	**$1.9m**	**$1.9m**

While the annual rates of return experienced by each path are quite different, the final balances (that is, the total retirement nest egg) are essentially the same. The 40-year accumulation path ending 1978 has an arithmetic (geometric) return 71 (33) basis points per annum or 8.17 (3.95) per cent per annum greater than the 1942 path, yet the terminal wealth outcome is virtually identical (the 1942 path actually beats the 1978 final account balance by around $500). Sequencing risk is the key reason the accumulation path ending in 1978 is reduces wealth so severely in the final years of accumulation. Figure 14 illustrates the two (1942 and 1978) wealth paths over their 40-years of accumulation. It is important to note that at age 55, these two paths have an accumulation of $730,000 and $1.1 million for 1942 and 1978 respectively, yet they both end up with total accumulated wealth of $1.9 million.

Figure 14 helps illustrate the final years of accumulation for both paths and shows the large negative return experienced by the 1978 path just six years from retirement (which represents 1973 return, followed by a large below mean return in 1974), severely affecting the portfolio. Even with the positive returns at the end of the accumulation period, it is difficult to recuperate from these losses and there is insufficient time to return the wealth trajectory to the level before these negative returns.

Figure 14: Two 40-year default strategy accumulation paths for years ending 1942 and 1978



4. HOW TO CONSIDER THE 'KNOWN UNKNOWNS' OF SEQUENCING RISK

In a now infamous US Department of Defense briefing in February 2002, the then Secretary of Defense, Donald Rumsfeld, stated 'there are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know'. It seems that in the sequencing risk debate there are some 'known unknowns'; that is, there is over a century of empirical return data to sample from, but given the 40-year accumulation horizon in a typical DC plan (and much longer if the full decumulation phase is included), there are relatively few paths (73) to consider. Many different outcomes are possible for the order of returns. Hence, DC plan members face a 'known unknown'.

A further complication is that in order to appreciate fully the impact of sequencing risk, many of the input variables need to be kept constant so the focus can be on the interplay between the final accumulated balance in a DC plan and the order of returns. The literature provides some excellent examples of various return-generating methodologies based on stochastic bootstrap and factor-based approaches.[19] However, the challenge for this study is to generate return paths from these approaches which may not hold all other variables constant to measure sequencing risk (that is, these generated paths may not have the same mean, standard deviation, skewness and excess kurtosis), making comparability difficult. Hence, the challenge is to find a methodological approach that holds these known measures of risk constant to evaluate sequencing risk.[20]

The bootstrap approach is used to 'shuffle' the returns, with the defining feature being the resampling without replacement. Each 40-year period is taken and the returns shuffled within that period a total of 10,000 times. (This results in 73 historical return paths x 40 annual returns x 10,000 times, a total of 29.2 million return points. Then 730,000 different final balances were generated for the hypothetical member at age 65 and these figures are presented in figure 15.) In figure 4, one actual return path (1974–2011) was taken and one reshuffle of the path (reverse ordered) was made. Here, 10,000 reshuffles are undertaken to quantify the impact of sequencing risk. The percentiles of the distribution are taken to create a heat map illustrated in figure 15.[21]

Figure 15 further highlights the impact that the order of returns potentially has on terminal wealth.[22] The horizontal axis represents the year in which the 40-year accumulation path ends while the vertical axis represents the final portfolio balances of that particular path where the returns are reshuffled 10,000 times and applied to the hypothetical DC plan member aged 25 years. The black line in figure 15 represents the final balance the member would receive if the historical path were repeated over the 40-year accumulation phase.[23] In summary, this line represents the actual final portfolio balances which the hypothetical DC plan member would receive if the path of returns over the 40-year period selected were to occur. It is interesting to track this line closely through the different periods. The line tracks into the 7th percentile in the path ending 1974 and enters the 92nd percentile in the path ending 2000. The respective percentile values, actual portfolio values and actual portfolio value

19. Bootstrap, Monte Carlo distributions and Economics Scenario Generators (ESGs) are some of the methods commonly found in the literature. See, for example, Blake, Cairns and Kevin (2001, 2003); Frank, Mitchell and Blanchett (2010, 2011); Basu and Drew (2009a); Basu, Byrne and Drew (2011); Dolvin, Templeton and Rieber (2010); Antolin, Payet and Yermo (2010); Mowbray (2010); and Scheuenstuhl et al. (2010). The bootstrap approaches presented in the literature create multiple paths by resampling with replacement. Such studies have differing moments of distribution and thus conclusions cannot be drawn about the unique impact of sequencing risk. A similar concern can be levelled at Monte Carlo simulations. ESGs draw on economic data and correlations with asset returns through time to produce scenarios which, by their nature, do not hold the four moments of the distribution constant. In no way are these respective approaches being rejected. They play an important role in the DC debate (with various papers by the authors, see Basu and Drew (2009a) employing a range of these techniques); however, for the research questions posed in this study, comparability of paths is key.

20. To quantify the impact of sequencing risk, the assumptions to produce the wealth outcomes and the paths' respective four moments of the distribution need to be held constant. Frank and Blanchett (2010) simulate sequencing risk by 'equalising' the mean and standard deviation of a Monte Carlo distribution. While this is an interesting approach, the motivation of this paper is to show sequencing risk when all assumptions and when all four moments are held constant. Dichev (2007) uses a simple, yet intuitive, technique to produce his results via a bootstrap method, which does not use resampling. The approach here, which simply shuffles the return series, all four moments to be retained constant, allowing sequencing risk to be quantified.

21. It is important to note that even shuffling these 40-year paths 10,000 times does not capture every possible combination. The total number of combinations which can be found is 8.159×10^{47}. This number is derived as the probability for the first number is 1 in 40, the second return is 1 in 39 and so on. It is known as a factorial of 40 (40x39x38x...x1). The maximum and minimums plotted in figure 15 do not represent the global maximum and minimum which can be found in the total number of combinations but rather the local extremes found in the 10,000 resampled paths.

22. Basu and Drew (2009a, 2010); and Antolin, Payet and Yermo (2010) are followed by reporting the retirement wealth ratio (RWR), which compares the terminal DC plan member's final year earnings to the terminal wealth of the plan, as a benchmark to evaluate different outcomes. Other objective functions may include the use of annuity equivalent values (AEVs). All of these measures attempt to provide some anchor regarding terminal wealth as a multiple of final salary (RWR) or the potential income stream that may be derived from terminal wealth.

23. For instance, 1939 represents a final balance for the hypothetical DC plan member aged 65 in 2052 of $2.3 million, a full list of final balances (and distributions) is provided in appendices 1 and 2.

percentiles for these paths are presented in table 5. The most recent 40-year accumulation path (1972–2011) is indicated in table 5.

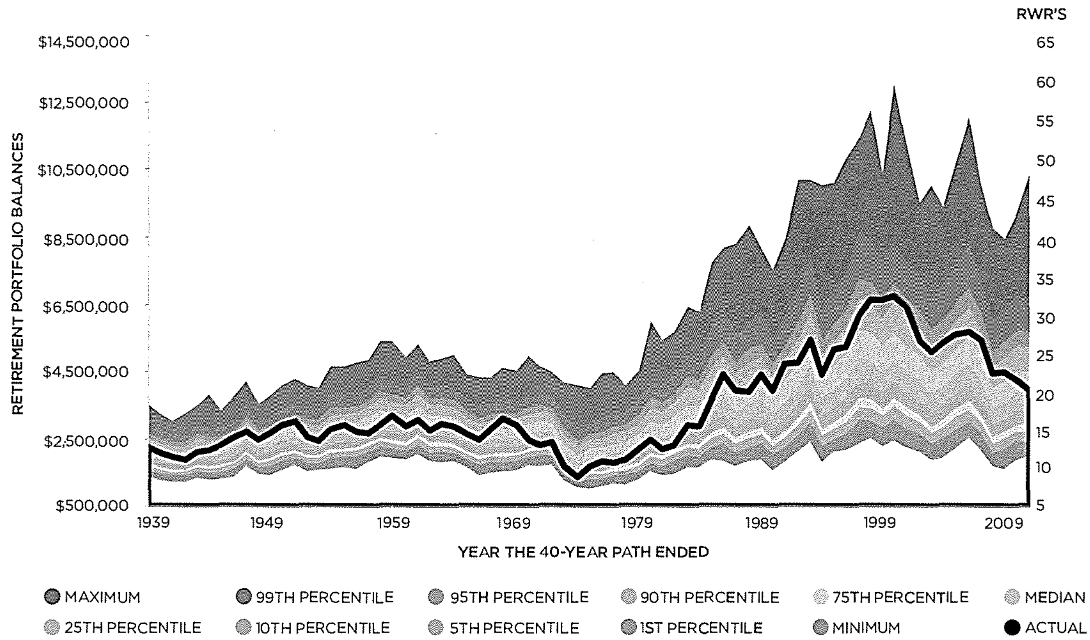
It can be seen that a DC plan member experiencing a path similar to 1974 would have had the worst outcome over the past century. The 1974 crash saw markets fall over a quarter of their value and the default strategy used in this study experienced a -12 per cent return for the year. This was coupled with the previous year (1973) recording a -22 per cent fall, quite literally the worst returns at their worst time.

Returning to table 5, the actual return for the 1935–1974 path landed in the 7th percentile of the simulation, while the 1961–2000 path landed in the 92nd percentile. These two extremes highlight that the extreme outcomes shown in figure 15 may not be completely unrealistic, and could occur in the future. The distribution of outcomes in figure 15 gives a range of possibilities that could play out in the future.[24]

Restricting the range of outcomes to the inter-quartile ranges, 34 out of the 73 actual 40-year paths lie outside their respective quartile ranges.[26] This again supports the view that the distributions of outcomes in figure 15 are not unrealistic, with almost half of the 40-year paths resting beyond their respective inter-quartile ranges.

It is a sobering thought that while the global financial crisis has raised significant debate about its impact on DC plans, the 40-year periods ending 2008, 2009 and 2010 were challenging but did not produce the worst order of returns in recent financial history. However, one caveat to this is that while the hypothetical DC plan member does not deviate from contributing nine per cent of wage and salary to superannuation annually, this is not the reality for most DC plan members. They tend to back-load their contributions (say, when the mortgage is paid off and dependents have left home), making the sequencing risk profile for uneven contributions even more dramatic. While this modeling is left to future research, the importance of the timing of these large contributions is acknowledged.

Figure 15: The default strategy's annual returns are used to determine every 40-year accumulation path from 1900 to 2011. (These were reshuffled via a bootstrap method 10,000 times each to simulate 10,000 final portfolio balances; assumptions about wealth creation are illustrated in table 1.)



24. One of the interesting results from the confirmatory analysis using real returns was the percentile that the actual paths experienced ranged from below the 5th percentile to above the 95th percentile (appendix 3).

25. See appendices 1 and 2 for final account balances (and percentiles) presented in figure 15.

Table 5: Actual final account balances with percentiles of the distributions for the worst 40-year accumulation path, best 40-year accumulation path and the most recent 40-year accumulation path using the default strategy's annual returns and the assumptions from table 1

	1935–1974 (WORST)	1961–2000 (BEST)	1972–2011 (MOST RECENT)
Minimum	$1,060,183	$2,445,751	$1,977,212
1st percentile	$1,221,898	$3,094,457	$2,424,586
5th percentile	$1,336,596	$3,468,941	$2,730,901
10th percentile	$1,416,253	$3,703,808	$2,935,151
25th percentile	$1,573,718	$4,182,929	$3,328,848
50th percentile	$1,778,886	$4,838,148	$3,865,317
75th percentile	$2,027,063	$5,654,434	$4,521,889
90th percentile	$2,283,077	$6,574,957	$5,230,972
95th percentile	$2,452,383	$7,126,916	$5,682,110
99th percentile	$2,768,281	$8,349,384	$6,683,261
Maximum	$4,117,753	$13,037,075	$10,363,284
Actual	$1,365,407	$6,745,033	$3,951,186
Actual percentile	6.58%	91.83%	53.93%

5. HOW TO MANAGE SEQUENCING RISK

The problem of sequencing risk arises because of the regular contributions going into the portfolio at every period of the investment horizon. Put simply, if the member were to make one single lump sum contribution at the beginning of the horizon, the accumulation at the end of the investment horizon would be dependent on the returns of every period but not on the sequence in which they occur. In this case, the sequence of returns would be irrelevant to the investor. On the other hand, regular contributions (or distributions) into the member account make the sequence of returns influential in determining final wealth outcomes. While sequence of returns would still be relevant with equal dollar contributions every period, the fact that the contributions are unequal over time make the risk more acute. As the contributions generally increase over the working life of individuals, it leads to their being better (worse) off when experiencing the best (worst) returns in the years leading up to retirement and the worst (best) ones early in their career.

Having established both the existence of sequencing risk confronted by all superannuation fund members and quantifying its impact on their retirement portfolio value, the logical question that follows is: how should it be managed? The age-old cure of diversification between different asset classes does not directly address this problem.[26] To devise strategies to manage sequencing risk, one needs to acknowledge the source of this risk as indicated above.

It is the periodic contributions by members that produce sequencing risk. Moreover, inequality in lifetime contributions turns this risk into an 800-pound gorilla as members approach retirement. Any strategy claiming to reduce sequencing risk needs to confront this inequality in contributions over the investment horizon.

Two ways are suggested to spread contributions more evenly over the working life of the investors thereby reducing sequencing risk. First, the contribution rates could be set higher initially and gradually brought down as one approaches retirement. This would make contribution sizes increase (decrease) in the earlier (later) part of the horizon thereby directly addressing the unequal contribution problem. By setting a higher contribution rate when incomes are typically lower and lower contribution rates when incomes are generally higher, the gap between contribution sizes at different lifecycle stages could be minimised. This could be achieved by setting the highest and the lowest contributions rates around an average lifetime contribution rate. (This may be equal to the current or future mandatory superannuation guarantee provisions.) The obvious difficulty in implementing such a policy would be the reluctance of investors to put more money into superannuation when they are younger, leaving less income for consumption.

The alternative to setting unequal contribution rates would be to adjust asset allocation over the working life to achieve higher portfolio exposure to growth assets in the early years than occurs with existing exposure levels. This would imply embracing a whole-of-life approach to DC plan design that invests mostly in equities in the initial and middle years but switches towards less volatile assets when approaching retirement. This is in contrast to the target risk or fixed allocation strategy adopted by most Australian superannuation funds in which the same proportion of equities (and other assets) exists for workers joining the workforce as those that are leaving it (Towers Watson 2012). A differential allocation across the investor's working life is suggested that can be built around an average dollar-weighted allocation, which is similar to the default asset allocation of the average superannuation fund. The investor would push up equity exposure to near 100 per cent at the beginning of their career but reduce it very aggressively in the years approaching retirement.[27] This strategy would allow for robust portfolio growth in the early years but cushion the impact of stock market downturns in the final years.[28]

26. This is not to deny that a diversified portfolio may dampen the amount of sequencing risk in a portfolio, which consists of only equities. There is a very important debate emerging around this issue, see Leibowitz and Bova (2009).

27. A higher than 100 per cent exposure to equities in the early years can also be achieved using call options on equity indices. This would allow for reductions in the equity exposure of the portfolio over time at a much faster rate than would otherwise occur (Ayres and Nalebuff 2010). Investors may also consider a dynamic approach to asset allocation informed by their retirement outcome objectives (Basu, Bryne and Drew 2011).

28. While the discussion is specifically focused on the core elements of sequencing risk, it is noted that a range of other practical strategies may be available to members. In addition to changes to the asset allocation through different life stages, other strategies may include: additional contributions (although it is noted that the issue of back-loading voluntary contributions in the years immediately preceding retirement may actually exacerbate sequencing risk); tax incentives for making contributions earlier in the accumulation phase; the potential to delay retirement (in reality, there may be some flexibility as to the retirement date); and tail insurance (downside risk overlays). These are all part of the broader debate.

CONCLUSION

Conventional wisdom suggests that, given a certain level of contributions, retirement wealth depends on the number of good and bad return periods experienced over a lifetime and the magnitude of those good and bad returns. In this paper, it has been demonstrated that the retirement wealth of long-term investors with multiple cash flows is not only affected by the frequency and magnitude of good and bad returns, but also by the sequence in which those returns occur. In short, the potential for DC plan members to experience the *worst returns in their worst order* should be seen as an important risk. Multi-period investors with identical average returns and volatilities over their lifetime will confront vastly different retirement wealth outcomes if the periodic returns are experienced in different orders or sequences.

Unfortunately, the sequence of market returns is beyond the control of investors, posing a real risk that returns will not follow their preferred sequence and therefore have adverse effects on their retirement nest egg. So, who owns the risk? In a DC-oriented system like that in Australia, it seems that sequencing risk adds to the range of other important risks (such as inflation, market, liquidity and longevity) faced by plan members.[29] Sequencing risk has a pervasive effect on the sustainability of retirement income for DC plan members. The risk particularly is acute around the period in which retirement savings are at their zenith.

In the foreword reference was made to the wisdom of Samuel Taylor Coleridge who described poetry as 'the best words in their best order'. The works of Coleridge and his contemporaries (Blake, Byron, Shelley, Keats and Wordsworth) saw the emergence of Romanticism in the late 18thcentury, a literary movement that placed new emphasis on individual uniqueness.[30] The findings in this paper suggest that there are two possible ways of diluting the impact of sequencing risk: adopting a strategy that either reduces the portfolio size effect (by spreading dollar-weighted allocations more evenly over one's investment life) or taking a whole-of-life approach to DC plan design. Investment markets do not afford the luxury of rearranging and reordering returns to find the perfect sequence. However, there is an opportunity to enhance retirement outcomes in DC plans through better understanding the individual uniqueness of plan members.[31]

The omnipresent nature of sequencing risk demands new thinking and approaches to managing the problem of 'the worst returns in their worst order'. Perhaps like the poets from the Romantic era, a new movement in retirement saving framed around the individual uniqueness of DC plan members is needed, shifting from a debate where success is framed around time-weighted metrics (risk, reward and peers) to the things that matter for investors — dollar-weighted returns.

To improve retirement outcomes for members, there is a need to ensure that the conversation about the management of sequencing risk, which often occurs during the critical retirement conversion phase, is brought forward to be at the heart of DC plan design and governance. This involves considering the impact of sequencing risk during an investor's pre- and early-retirement phase (say, the final 15 years of the accumulation period and the first decade of the distribution phase). Particularly during this critical conversion phase, many investors are unaware that it is not the average return of their investments, but the realised sequence of those returns, that can largely determine the sustainability of their retirement income. With increasing numbers of baby boomers entering this phase, the sequence of returns risk is a current and significant challenge.

29. The challenges that sequencing risk may pose for public policy are formally acknowledged, particularly for the provision of the public pension. Potentially, sequencing risk fragments outcomes for members of DC plans and, as a result, this is problematic in terms of policy outcomes. It is submitted that this line of investigation is important and future researchers are encouraged to consider sequencing risk more formally through the lens of public finance. The importance of sequencing risk for self-managed superannuation funds (SMSFs) is also noted and this issue is left for future researchers.

30. For an overview of this period in literary history see the website maintained by Professor Robert Schwartz at: https://www.mtholyoke.edu/courses/rschwart/hist255/index.html and the BBC's online resource: www.bbc.co.uk/arts/romantics/

31. Potentially, sequencing risk is not only borne by an individual. The problem for public policy arises when it is not just one individual who suffers a large loss on their retirement savings, but an entire cohort that endures the same loss. This is a realistic scenario with around 80 per cent of all Australians being enrolled in the default option and thus experiencing similar return paths with only minor differences between fund default strategies (Towers Watson 2012).

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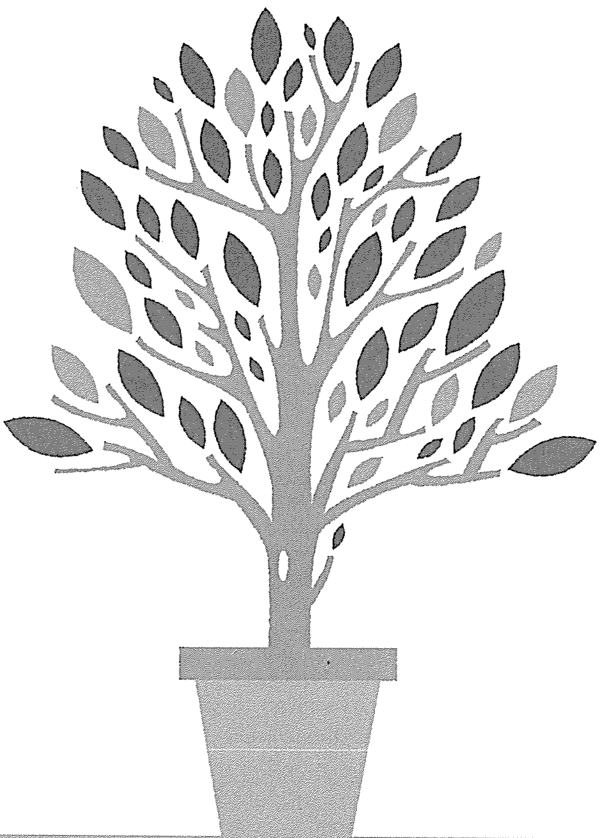
and appendices



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APPENDICES

Appendix 1

Table A1: Actual final account balances along with mean, median, standard deviation and interquartile range for the final portfolio balances from figure 15.

RETIREMENT YEAR	ACTUAL	MEAN	MEDIAN	STANDARD DEVIATION	INTERQUARTILE RANGE
1939	$2,254,561	$2,113,273	$2,087,697	$290,253	$389,384
1940	$2,106,244	$1,979,401	$1,952,584	$279,014	$374,527
1941	$1,988,646	$1,921,716	$1,893,125	$270,545	$364,094
1942	$1,912,914	$1,913,458	$1,888,584	$263,483	$356,999
1943	$2,117,844	$2,111,708	$2,082,327	$297,507	$397,483
1944	$2,158,523	$2,052,776	$2,024,008	$292,028	$393,801
1945	$2,322,076	$2,059,661	$2,032,699	$287,245	$382,897
1946	$2,565,106	$2,208,271	$2,177,477	$312,945	$424,395
1947	$2,737,684	$2,553,221	$2,516,230	$344,582	$461,369
1948	$2,472,006	$2,222,161	$2,191,558	$302,354	$403,598
1949	$2,684,972	$2,311,842	$2,282,826	$314,067	$424,786
1950	$2,911,902	$2,514,374	$2,482,831	$343,250	$460,366
1951	$3,026,912	$2,608,966	$2,569,532	$352,133	$474,159
1952	$2,557,093	$2,432,172	$2,399,244	$354,556	$473,905
1953	$2,455,178	$2,429,412	$2,396,037	$348,679	$470,924
1954	$2,797,518	$2,680,340	$2,635,648	$404,250	$536,983
1955	$2,938,755	$2,707,861	$2,665,877	$402,390	$544,860
1956	$2,725,540	$2,738,293	$2,699,814	$404,501	$539,887
1957	$2,687,332	$2,902,485	$2,856,789	$417,409	$552,710
1958	$2,921,886	$3,089,505	$3,039,938	$454,966	$606,436
1959	$3,189,883	$3,014,345	$2,967,587	$437,116	$582,619
1960	$2,896,965	$2,929,841	$2,884,227	$429,935	$584,309
1961	$3,061,133	$3,199,575	$3,147,037	$467,002	$617,854
1962	$2,775,025	$2,915,790	$2,868,665	$436,471	$584,936
1963	$2,964,702	$2,936,213	$2,896,585	$434,216	$582,161
1964	$2,879,472	$2,883,308	$2,842,458	$426,660	$568,787
1965	$2,657,903	$2,608,493	$2,569,008	$391,008	$517,213
1966	$2,467,391	$2,453,002	$2,409,882	$376,654	$499,080
1967	$2,790,946	$2,525,067	$2,483,095	$385,345	$515,853
1968	$3,099,550	$2,562,871	$2,520,031	$399,302	$526,109
1969	$2,937,397	$2,575,739	$2,536,151	$392,761	$527,030
1970	$2,505,565	$2,703,758	$2,665,929	$394,348	$527,827
1971	$2,344,418	$2,781,385	$2,739,748	$397,232	$533,929
1972	$2,402,492	$2,723,568	$2,683,892	$387,024	$516,229
1973	$1,702,719	$2,125,635	$2,079,800	$370,854	$488,676
1974	$1,365,407	$1,821,738	$1,778,896	$341,777	$453,344

Appendix 1 continued

Table A1: Actual final account balances along with mean, median, standard deviation and interquartile range for the final portfolio balances from figure 15.

RETIREMENT YEAR	ACTUAL	MEAN	MEDIAN	STANDARD DEVIATION	INTERQUARTILE RANGE
1975	$1,684,724	$1,965,612	$1,917,518	$373,950	$496,179
1976	$1,856,321	$2,015,490	$1,968,591	$395,861	$519,301
1977	$1,831,910	$2,122,200	$2,073,001	$410,064	$537,747
1978	$1,912,408	$2,155,849	$2,107,809	$409,411	$546,169
1979	$2,216,658	$2,363,151	$2,303,843	$461,338	$602,412
1980	$2,498,472	$2,702,380	$2,631,773	$532,772	$693,371
1981	$2,197,830	$2,606,769	$2,532,474	$520,710	$680,186
1982	$2,324,536	$2,816,167	$2,738,589	$562,417	$742,140
1983	$2,926,721	$3,135,525	$3,046,556	$647,115	$853,730
1984	$2,877,770	$3,102,739	$3,021,500	$635,537	$834,689
1985	$3,690,741	$3,562,499	$3,445,726	$771,700	$985,462
1986	$4,415,392	$3,824,436	$3,706,042	$853,940	$1,089,755
1987	$3,957,557	$3,407,855	$3,303,653	$761,919	$970,869
1988	$3,920,999	$3,661,888	$3,544,493	$810,101	$1,063,693
1989	$4,435,775	$3,819,069	$3,706,549	$839,170	$1,092,973
1990	$3,950,782	$3,351,805	$3,248,150	$750,956	$991,183
1991	$4,729,799	$3,717,758	$3,608,310	$846,623	$1,103,896
1992	$4,762,183	$4,214,830	$4,081,862	$936,613	$1,199,611
1993	$5,458,357	$4,828,580	$4,681,492	$1,068,879	$1,402,418
1994	$4,431,367	$3,832,133	$3,715,482	$882,518	$1,144,519
1995	$5,168,319	$4,133,905	$3,993,918	$961,582	$1,244,961
1996	$5,260,199	$4,426,992	$4,279,258	$1,021,787	$1,303,576
1997	$6,196,753	$5,064,783	$4,895,516	$1,192,073	$1,536,463
1998	$6,638,491	$4,994,514	$4,824,765	$1,156,146	$1,489,704
1999	$6,635,902	$4,645,265	$4,481,280	$1,073,338	$1,382,474
2000	$6,745,033	$5,011,016	$4,838,180	$1,147,267	$1,471,505
2001	$6,440,124	$4,659,254	$4,511,846	$1,075,845	$1,390,124
2002	$5,415,275	$4,386,920	$4,239,448	$1,027,357	$1,327,080
2003	$5,112,356	$3,990,709	$3,840,308	$953,197	$1,240,966
2004	$5,359,401	$4,192,396	$4,051,683	$979,442	$1,264,079
2005	$5,619,289	$4,586,313	$4,434,818	$1,058,751	$1,362,777
2006	$5,692,991	$4,898,547	$4,739,224	$1,127,596	$1,465,654
2007	$5,452,789	$4,365,471	$4,219,124	$1,001,879	$1,307,381
2008	$4,471,435	$3,544,531	$3,426,442	$846,360	$1,097,309
2009	$4,504,210	$3,727,461	$3,594,060	$896,159	$1,145,286
2010	$4,250,055	$4,016,346	$3,879,309	$933,097	$1,194,875
2011	$3,951,186	$3,992,801	$3,865,759	$920,733	$1,193,041

Appendix 2

Table A2: Percentiles for distributions of outcomes from figure 15, each row represents the terminal wealth balance for a 40-year accumulation path.

RETIREMENT YEAR	1ST PERCENTILE	5TH PERCENTILE	10TH PERCENTILE	25TH PERCENTILE	MEDIAN	75TH PERCENTILE	90TH PERCENTILE	95TH PERCENTILE	99TH PERCENTILE
1939	$1,564,339	$1,684,413	$1,761,519	$1,901,988	$2,087,684	$2,291,372	$2,503,343	$2,637,411	$2,878,911
1940	$1,461,873	$1,577,053	$1,646,583	$1,775,481	$1,952,582	$2,150,008	$2,349,174	$2,489,767	$2,752,172
1941	$1,402,235	$1,516,871	$1,592,542	$1,729,003	$1,893,121	$2,093,097	$2,283,296	$2,404,224	$2,660,492
1942	$1,418,821	$1,525,155	$1,590,012	$1,722,197	$1,888,560	$2,079,196	$2,264,329	$2,389,749	$2,610,084
1943	$1,543,463	$1,672,648	$1,754,081	$1,899,299	$2,082,216	$2,296,782	$2,506,550	$2,655,383	$2,910,823
1944	$1,500,667	$1,628,320	$1,701,889	$1,842,450	$2,024,008	$2,236,251	$2,440,963	$2,576,946	$2,848,074
1945	$1,509,357	$1,636,800	$1,715,508	$1,850,376	$2,032,692	$2,233,273	$2,446,742	$2,574,565	$2,839,461
1946	$1,612,993	$1,755,423	$1,831,613	$1,980,660	$2,177,469	$2,405,055	$2,620,834	$2,769,498	$3,046,891
1947	$1,900,309	$2,047,051	$2,141,593	$2,304,776	$2,516,189	$2,766,146	$3,013,203	$3,173,838	$3,499,303
1948	$1,650,038	$1,781,441	$1,860,597	$2,003,347	$2,191,486	$2,406,945	$2,626,306	$2,767,771	$3,034,791
1949	$1,711,943	$1,848,045	$1,924,960	$2,085,542	$2,282,812	$2,510,328	$2,730,194	$2,871,166	$3,132,916
1950	$1,860,502	$2,012,331	$2,098,233	$2,265,550	$2,482,799	$2,725,916	$2,973,545	$3,120,841	$3,443,301
1951	$1,944,249	$2,089,954	$2,181,686	$2,356,049	$2,569,465	$2,830,208	$3,080,148	$3,251,593	$3,548,162
1952	$1,760,992	$1,918,668	$2,003,450	$2,173,648	$2,399,121	$2,647,553	$2,905,206	$3,075,299	$3,387,146
1953	$1,776,225	$1,923,013	$2,004,666	$2,175,872	$2,395,983	$2,646,795	$2,894,231	$3,064,965	$3,364,814
1954	$1,939,263	$2,097,406	$2,202,071	$2,387,130	$2,635,565	$2,924,113	$3,215,278	$3,418,079	$3,815,722
1955	$1,967,520	$2,125,196	$2,222,297	$2,415,824	$2,665,848	$2,960,684	$3,244,494	$3,422,627	$3,822,822
1956	$1,982,168	$2,151,584	$2,255,068	$2,444,731	$2,699,801	$2,984,618	$3,277,927	$3,469,294	$3,841,236
1957	$2,112,997	$2,288,740	$2,401,180	$2,604,840	$2,856,770	$3,157,550	$3,458,989	$3,644,492	$4,072,713
1958	$2,264,927	$2,434,655	$2,543,123	$2,757,253	$3,039,932	$3,363,689	$3,700,863	$3,917,824	$4,355,772
1959	$2,203,687	$2,383,597	$2,492,890	$2,698,370	$2,967,477	$3,280,989	$3,609,247	$3,814,736	$4,217,284
1960	$2,125,917	$2,307,533	$2,411,676	$2,614,985	$2,884,225	$3,199,294	$3,516,001	$3,704,743	$4,083,698
1961	$2,343,752	$2,518,315	$2,643,326	$2,863,273	$3,146,972	$3,481,127	$3,825,534	$4,048,797	$4,521,218
1962	$2,104,537	$2,283,446	$2,391,361	$2,599,684	$2,868,648	$3,184,620	$3,507,731	$3,712,310	$4,090,193
1963	$2,119,608	$2,296,950	$2,410,142	$2,621,909	$2,896,567	$3,204,069	$3,518,107	$3,724,417	$4,098,513
1964	$2,097,377	$2,264,326	$2,367,917	$2,572,815	$2,842,428	$3,141,602	$3,452,726	$3,657,426	$4,064,437
1965	$1,885,975	$2,036,503	$2,134,943	$2,330,321	$2,569,005	$2,847,535	$3,130,652	$3,315,566	$3,684,313
1966	$1,746,650	$1,912,238	$2,003,607	$2,184,044	$2,409,882	$2,683,123	$2,954,923	$3,125,833	$3,500,922
1967	$1,811,441	$1,965,569	$2,061,946	$2,249,231	$2,483,006	$2,765,084	$3,037,572	$3,222,418	$3,576,691
1968	$1,819,160	$1,986,638	$2,088,810	$2,274,424	$2,520,026	$2,800,533	$3,101,099	$3,283,489	$3,653,906
1969	$1,854,080	$2,001,447	$2,104,452	$2,291,876	$2,536,116	$2,818,907	$3,107,606	$3,279,200	$3,631,871
1970	$1,963,198	$2,119,700	$2,222,876	$2,418,504	$2,665,898	$2,946,331	$3,241,273	$3,418,470	$3,758,666
1971	$2,030,041	$2,199,792	$2,304,532	$2,495,234	$2,739,722	$3,029,164	$3,316,329	$3,498,233	$3,833,426
1972	$1,995,137	$2,159,750	$2,253,172	$2,446,309	$2,683,842	$2,962,537	$3,242,868	$3,413,639	$3,772,067
1973	$1,458,727	$1,608,069	$1,690,804	$1,857,600	$2,079,797	$2,346,276	$2,618,842	$2,803,399	$3,185,936
1974	$1,221,898	$1,336,596	$1,416,253	$1,573,718	$1,778,886	$2,027,063	$2,283,077	$2,452,383	$2,768,281

Appendix 2 continued

Table A2: Percentiles for distributions of outcomes from figure 15, each row represents the terminal wealth balance for a 40-year accumulation path.

RETIREMENT YEAR	1ST PERCENTILE	5TH PERCENTILE	10TH PERCENTILE	25TH PERCENTILE	MEDIAN	75TH PERCENTILE	90TH PERCENTILE	95TH PERCENTILE	99TH PERCENTILE
1975	$1,301,467	$1,442,097	$1,524,366	$1,694,346	$1,917,494	$2,190,524	$2,469,516	$2,645,554	$2,999,484
1976	$1,310,879	$1,458,859	$1,550,785	$1,729,122	$1,968,572	$2,248,423	$2,541,119	$2,724,419	$3,138,016
1977	$1,406,600	$1,551,774	$1,644,405	$1,820,745	$2,072,925	$2,358,492	$2,666,676	$2,877,790	$3,296,266
1978	$1,419,073	$1,579,026	$1,678,025	$1,854,042	$2,107,719	$2,400,211	$2,705,292	$2,916,048	$3,332,014
1979	$1,539,814	$1,714,392	$1,818,042	$2,030,364	$2,303,739	$2,632,776	$2,979,545	$3,222,371	$3,694,375
1980	$1,755,720	$1,963,097	$2,080,418	$2,315,963	$2,631,729	$3,009,334	$3,412,367	$3,699,058	$4,200,337
1981	$1,713,875	$1,885,672	$1,998,524	$2,227,097	$2,532,462	$2,907,283	$3,317,617	$3,588,960	$4,109,639
1982	$1,836,863	$2,035,526	$2,155,964	$2,408,053	$2,738,467	$3,150,193	$3,574,107	$3,850,233	$4,416,680
1983	$2,011,592	$2,235,499	$2,380,025	$2,663,914	$3,046,410	$3,517,645	$4,022,634	$4,327,043	$4,965,167
1984	$1,987,443	$2,219,313	$2,364,198	$2,645,276	$3,021,428	$3,479,964	$3,941,720	$4,254,357	$4,950,066
1985	$2,259,070	$2,514,169	$2,670,150	$3,005,946	$3,445,603	$3,991,408	$4,611,873	$4,993,037	$5,861,333
1986	$2,376,838	$2,661,446	$2,842,304	$3,206,503	$3,705,680	$4,296,258	$4,975,175	$5,382,544	$6,370,989
1987	$2,084,572	$2,364,611	$2,538,687	$2,861,177	$3,303,546	$3,832,046	$4,413,712	$4,797,664	$5,661,461
1988	$2,255,809	$2,539,258	$2,717,936	$3,075,344	$3,544,180	$4,139,037	$4,770,750	$5,171,576	$5,916,347
1989	$2,353,144	$2,654,642	$2,841,695	$3,209,815	$3,706,464	$4,302,788	$4,924,269	$5,343,547	$6,318,769
1990	$2,039,721	$2,305,346	$2,475,456	$2,804,779	$3,247,994	$3,795,962	$4,354,179	$4,752,415	$5,490,243
1991	$2,246,627	$2,545,153	$2,730,749	$3,105,909	$3,608,273	$4,209,805	$4,851,062	$5,272,645	$6,174,760
1992	$2,595,644	$2,933,900	$3,133,360	$3,539,178	$4,081,829	$4,738,789	$5,468,636	$5,955,665	$6,949,550
1993	$3,007,661	$3,357,169	$3,588,468	$4,048,018	$4,681,228	$5,450,436	$6,267,301	$6,782,899	$7,945,798
1994	$2,308,182	$2,624,070	$2,812,530	$3,186,160	$3,715,466	$4,330,679	$5,024,907	$5,465,902	$6,418,562
1995	$2,505,878	$2,813,855	$3,018,362	$3,434,035	$3,993,873	$4,678,996	$5,412,183	$5,937,037	$6,903,931
1996	$2,652,967	$3,012,890	$3,253,106	$3,696,393	$4,279,224	$4,999,969	$5,801,969	$6,339,504	$7,442,757
1997	$3,060,626	$3,446,129	$3,702,235	$4,200,486	$4,895,205	$5,736,949	$6,622,920	$7,285,705	$8,667,881
1998	$3,043,080	$3,392,098	$3,662,780	$4,160,464	$4,824,566	$5,650,168	$6,570,856	$7,170,796	$8,410,831
1999	$2,828,761	$3,197,069	$3,411,275	$3,875,605	$4,481,135	$5,258,078	$6,083,343	$6,657,549	$7,793,626
2000	$3,094,457	$3,468,941	$3,703,808	$4,182,929	$4,838,148	$5,654,434	$6,574,957	$7,126,916	$8,349,384
2001	$2,810,279	$3,190,012	$3,417,554	$3,880,137	$4,511,686	$5,270,262	$6,106,688	$6,668,939	$7,741,116
2002	$2,629,053	$2,982,089	$3,203,779	$3,643,282	$4,239,360	$4,970,363	$5,782,081	$6,292,419	$7,386,853
2003	$2,374,569	$2,695,101	$2,896,868	$3,300,967	$3,840,172	$4,541,933	$5,275,027	$5,779,018	$6,745,328
2004	$2,517,865	$2,853,033	$3,063,557	$3,477,362	$4,051,680	$4,741,440	$5,507,749	$6,027,425	$7,079,526
2005	$2,749,203	$3,148,332	$3,377,447	$3,821,664	$4,434,650	$5,184,440	$6,002,221	$6,521,983	$7,632,553
2006	$3,000,573	$3,357,526	$3,615,474	$4,078,734	$4,738,989	$5,544,388	$6,383,353	$7,007,943	$8,270,100
2007	$2,670,107	$2,993,034	$3,210,320	$3,640,209	$4,219,066	$4,947,590	$5,727,828	$6,229,056	$7,290,805
2008	$2,099,916	$2,384,381	$2,578,600	$2,931,266	$3,426,442	$4,028,575	$4,658,581	$5,078,963	$6,059,699
2009	$2,197,566	$2,507,709	$2,708,922	$3,083,831	$3,594,056	$4,229,117	$4,916,232	$5,416,196	$6,421,506
2010	$2,438,126	$2,737,959	$2,933,810	$3,347,508	$3,879,078	$4,542,383	$5,261,147	$5,718,282	$6,750,914
2011	$2,424,586	$2,730,901	$2,935,151	$3,328,848	$3,865,317	$4,521,889	$5,230,972	$5,682,110	$6,683,261

Appendix 3

The study uses nominal rates of return in its analysis. Nominal returns were used as the primary methodology because they have precedent in the retirement savings literature (Basu and Drew 2009a; Basu, Byrne and Drew 2011) and also in the broader time diversification literature (e.g. Hickman et al. 2001; Guo and Darnell 2005). Another important consideration for this study was to use history as a guide. To capture historical returns in their absolute form, the study required that historical inflation be included in the calculations. Recent literature suggests that inflationary values also drive market returns through behavioural finance. For instance, markets are commonly referred to as having a floor (or ceiling) which is a psychological barrier for investors (see Li and Yu 2012).[32] These market levels are based on nominal values, thus inflation is also a driver of returns and is not just reducing the value of money in an economy.

A further challenge in using real returns relates to the practical question of 'what is inflation?' Inflation figures are commonly found by using the Consumer Price Index (CPI).[33] The DMS database uses inflation measures from the GDP deflator (1900–1901), the Retail Price Index (1902–1948) and the CPI (1948–2011). Therefore, researchers are challenged by the generalisation of inflation (and the accuracy of its representation) when applied across multiple asset classes. However, while noting the various issues in the nominal-versus-real debate, there is merit in undertaking a confirmatory analysis using real returns. All of the experiments conducted in the body of the study have been replicated using real returns and contributions.[34] All of the original assumptions outlined in the study are held constant for this analysis. However, to keep in line with the reduction in inflation, the salary growth rate is reduced to two per cent per annum.[35] The key result from this replication using inflation-adjusted data is that it confirms the major findings of this study and, in some instances, points to the problem of sequencing risk being potentially an even greater issue for retirement outcomes.

Table A1 illustrates the summary statistics for the real return analysis. The results show a reduced annual long run average return by four per cent.

Table A3: Summary statistics for the default strategy's real returns (1900–2011)

VARIABLE	ASSUMPTION
Mean	6%
Standard deviation	12%

The analysis of the portfolio size effect using real returns corroborates the nominal findings. Figure A1 (a replica of figure 7) illustrates the cumulative contributions divided by the total portfolio size each year.

The results presented in figure A1 (a replica of figure 7) show that the age at which the investor's first 40-year accumulation path reaches the 50 per cent level (cumulative contributions/portfolio size) is not dissimilar to that of nominal figures. The first path occurs at approximately 34 years of age, identical to the nominal return analysis. The main study found an 80/20 rule of thumb when using nominal returns. The real return analysis supports this rule of thumb (albeit with a much wider distribution), with the average cumulative contributions in the final 10 years approximately 40 per cent of total portfolio size. In short, this is a 60/40 rule, versus an 80/20 rule using nominal data.

Figures A2 and A3 (replicas of figures 8 and 9) illustrate the return volatility over time when using real returns. Figure A2 shows the rolling three-year equity volatility from 1900 to 2011 while figure A3 provides a colour-coded histogram of the default strategy's annual real returns. As expected, both figures have a strong resemblance to those which are derived using nominal returns. Figure A3 shows the tails are still populated by the returns experienced later in the century and that the left tail of the distribution is more heavily populated.

32. These market floors (or ceilings) are not only seen in terms of total market capitalisation but also on an individual stock basis when observing the stocks 52-week highs and lows (see Li and Yu 2012). Psychological barriers are also found in international exchange rates, which fluctuate somewhat with respect to the differing levels of individual country inflation (see Mitchell and Izan 2006).

33. The CPI is a measure of the change in price of a basket of consumer goods over time. There are multiple calculation issues which arise when calculating the CPI (see Braithwait 1980; Manser and McDonald 1988; Lebow and Rudd 2003). There is also a question about which is a better measure of inflation — the CPI, which estimates consumer inflation, or the Producer Price Index (PPI) (see Tsiaplias 2008).

34. In the interest of brevity, only the key tables and figures are provided in this appendix, but others are available on request.

35. The value of two per cent real wage growth is commonly used in the literature (see, for example, Byrne etal. 2006; Basu and Drew 2010).

Figure A1: Total cumulative contributions as a percentage of total portfolio balance for all 40-year accumulation paths from 1900 to 2011 using the default strategy's annual real returns (n=73)

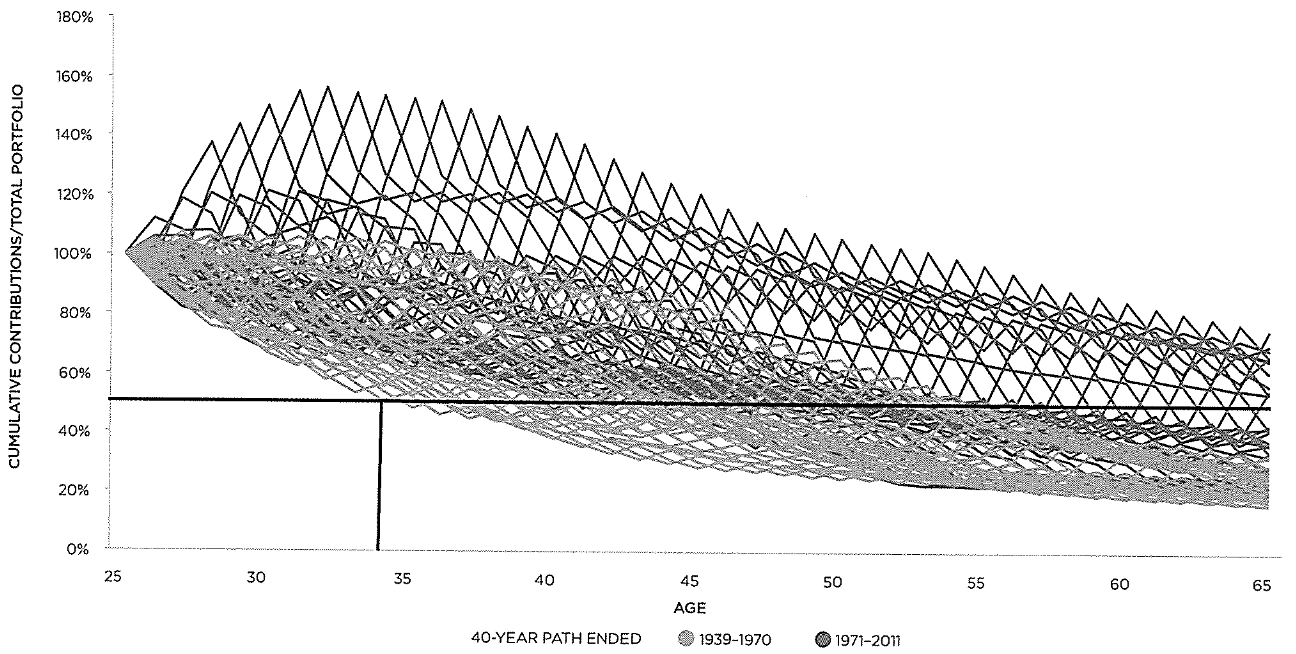


Figure A2: Rolling three-year Australian real return equity volatility from 1900 to 2011

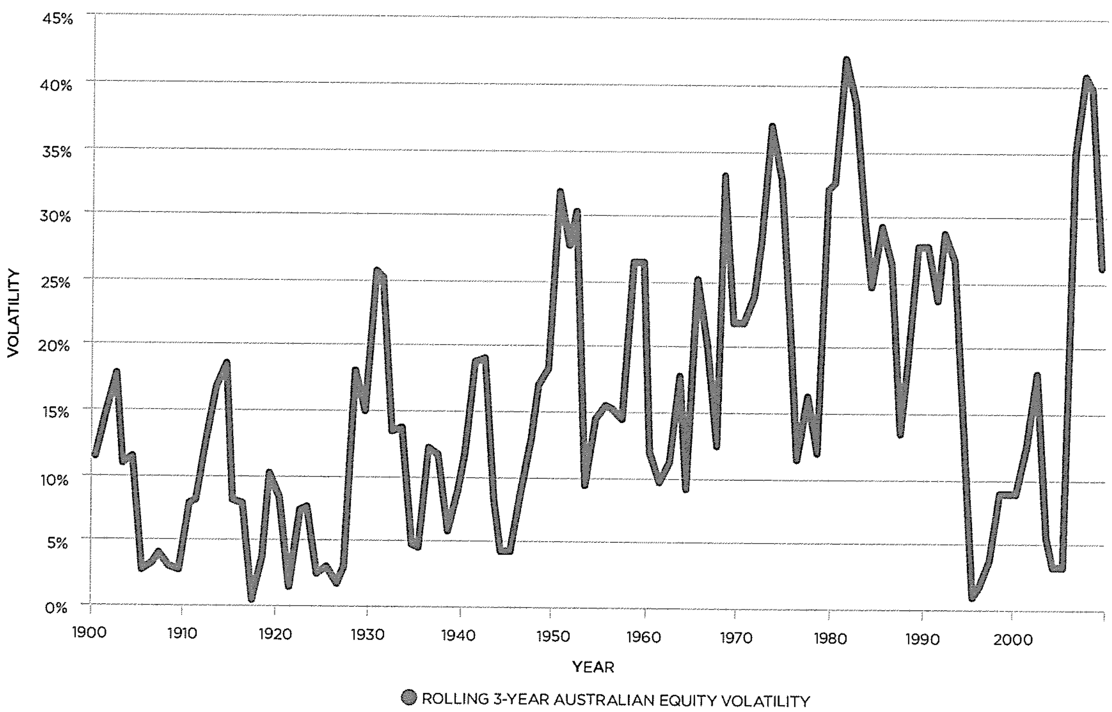


Figure A3: Histogram of the default strategy's annual real returns (1900-2011)

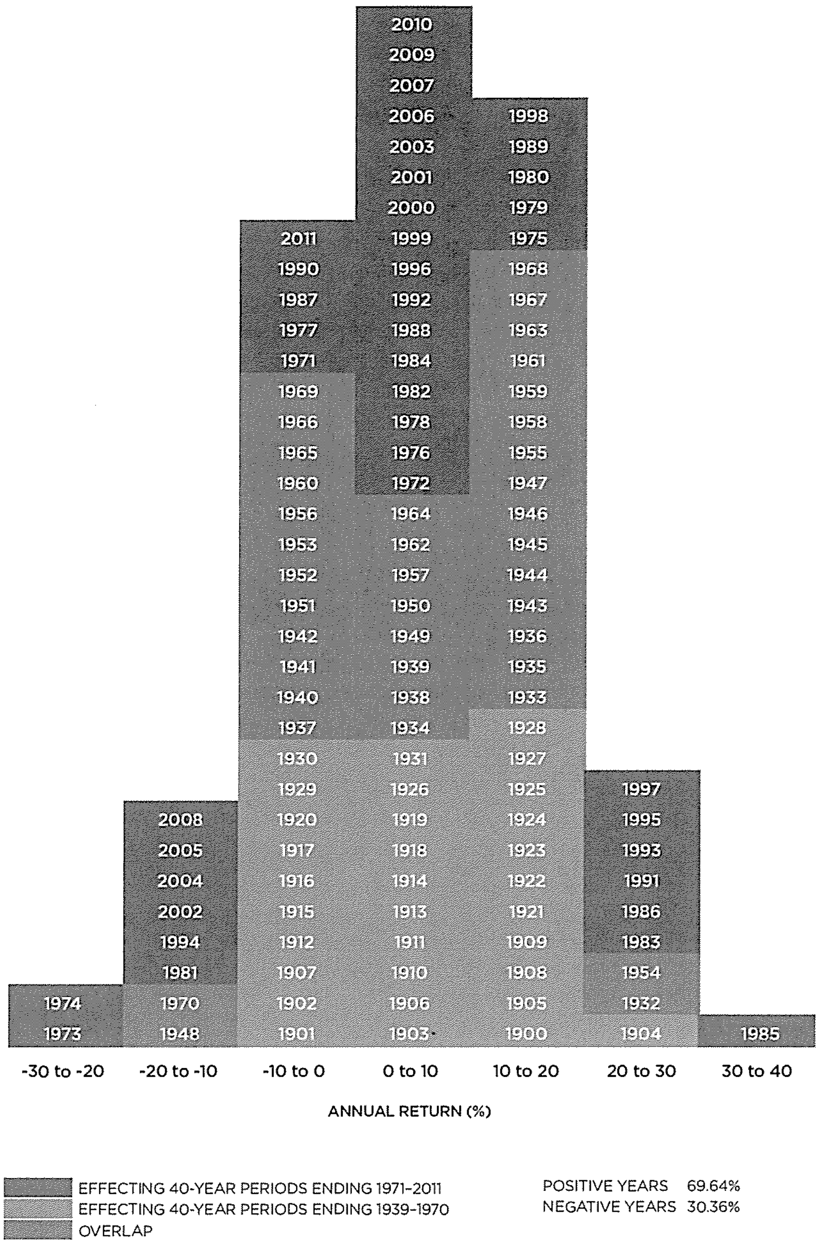
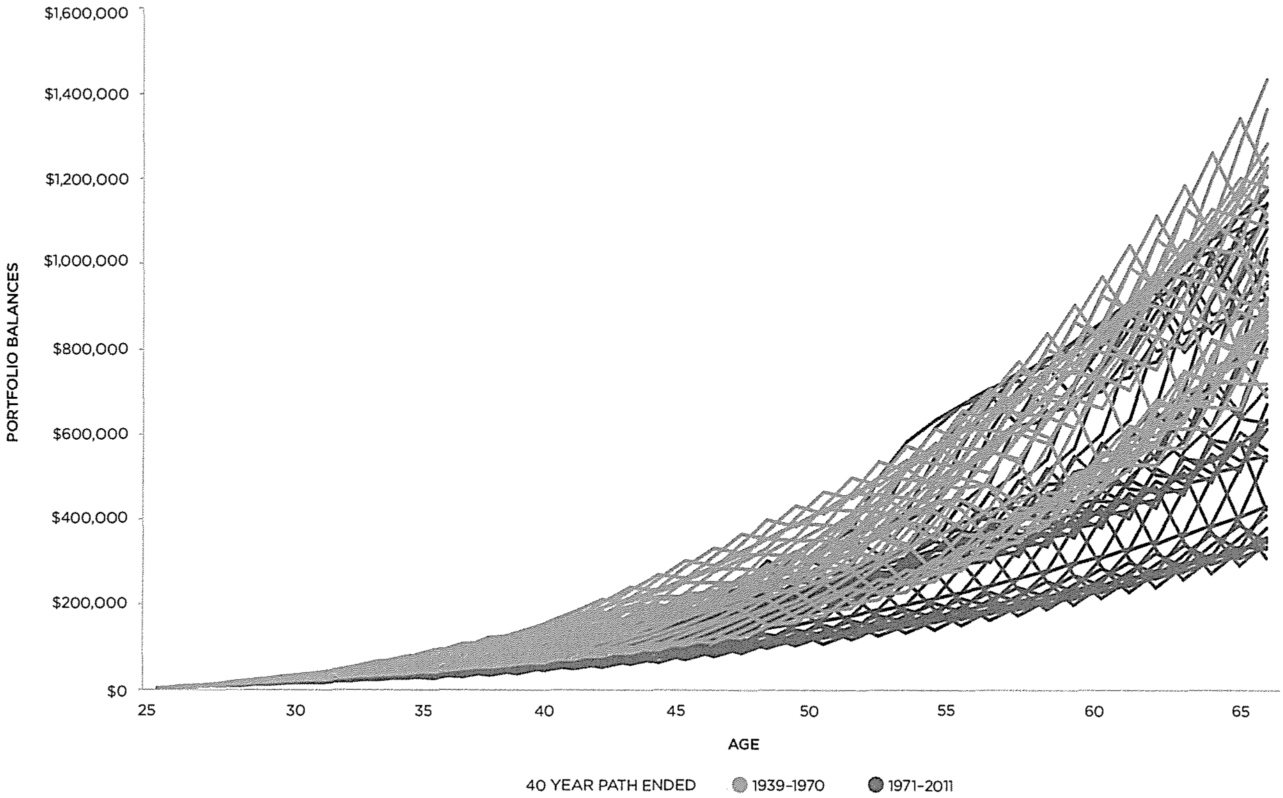


Figure A4: Every 40-year accumulation path from 1900 to 2011 using the default strategy's real annual returns (n=73)



When observing how the portfolios track through time, some differences in the order can be observed when comparing nominal and real returns. However, the main findings of the paper remain consistent. Figure A4 (a replica of figure 10), shows every 40-year accumulation path from 1900 to 2011; using real returns some of the red paths (representing 40-year paths ending from 1939 to 1970) outperform the blue paths (representing 40-year paths ending from 1971 to 2011). However, the main finding of the paper is that the range between the best and worst paths has been increasing over time; this is corroborated with the real return analysis, as seen in figure A4.

Figure A5: Heat map of the default strategy's annual real returns for every 40-year accumulation path from 1900 to 2011 (n=73)

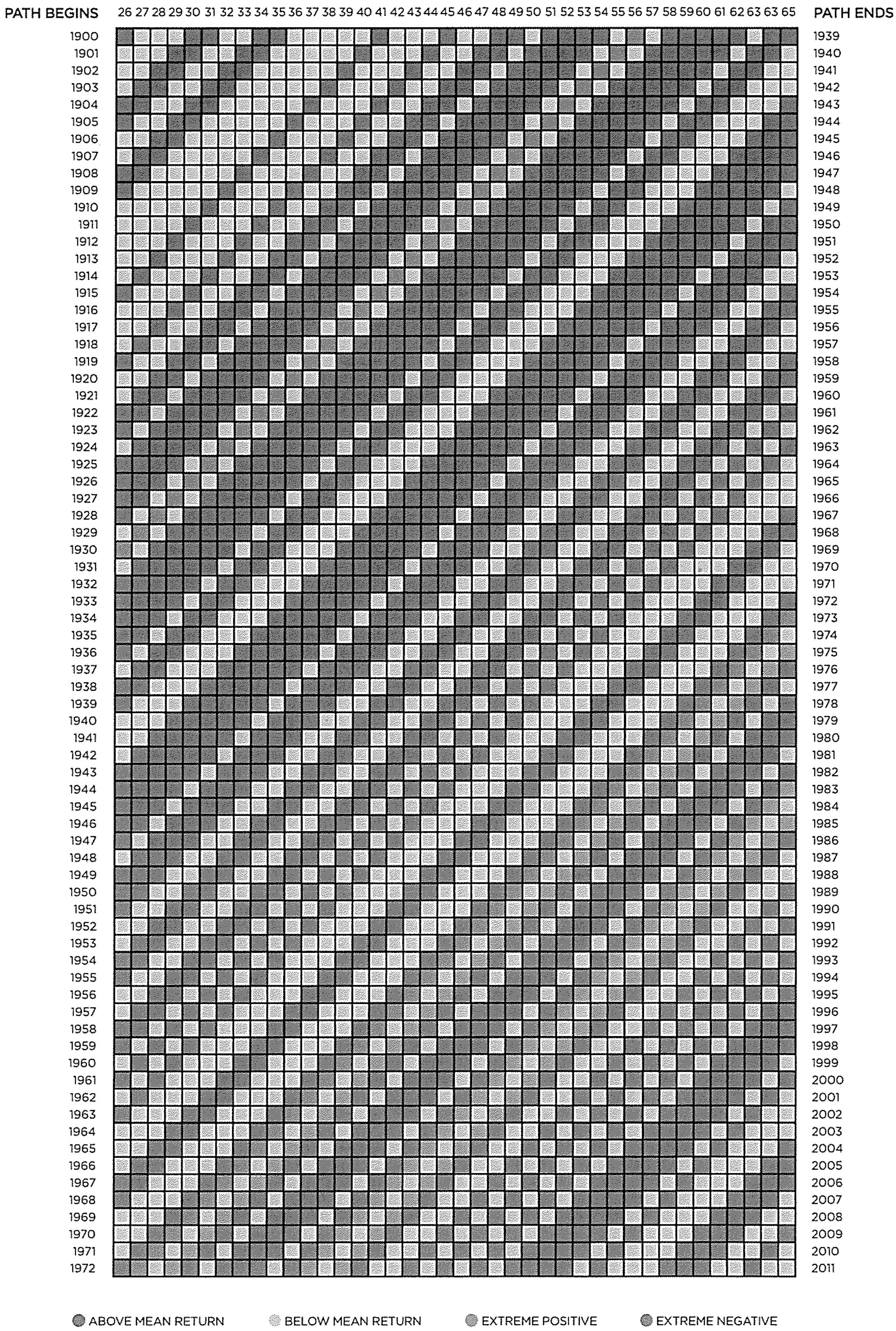
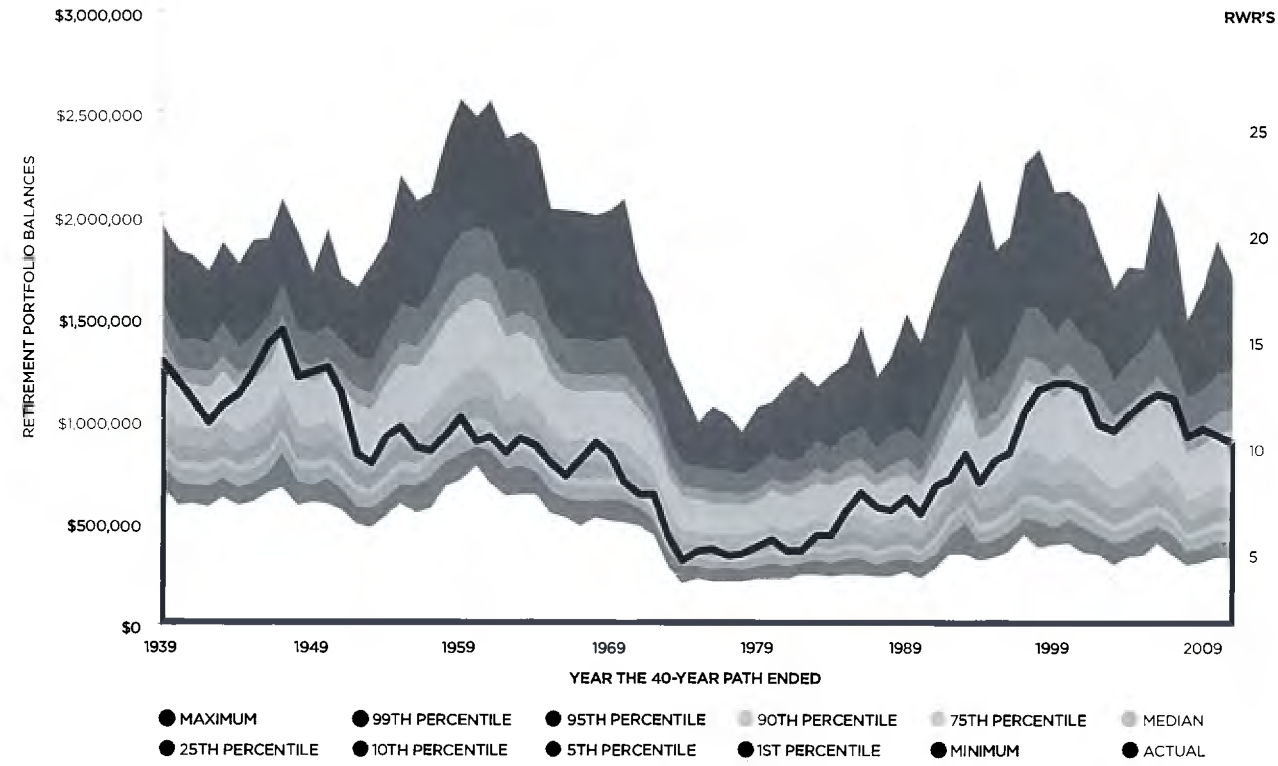


Figure A5 (a replica of figure 11) illustrates a heat map of the real returns. The colour coding follows the same methodology as used in the study.

Figure A6: The default strategy's annual real returns were used to find every 40-year accumulation path from 1900 to s2011. These were shuffled via a bootstrap method 10,000 times each to simulated 10,000 final portfolio balances.



Finally, figure A6 (a replica of figure 15) shows the shuffled bootstrap of every 40-year accumulation path. The same methodology is followed as in figure 15 in the study. The variability illustrated in figure A6 reflects the main themes resulting from using nominal returns.

The striking features of the real return analysis are the actual realised extremes. For example, the worst 40-year accumulation path is the 40-year path ending 1974 and this path falls into the fifth percentile in the real return analysis.

CONTACT DETAILS

Head Office/NSW and ACT
Level 16, 1 Margaret Street
Sydney NSW 2000
T > 61 2 9275 7900
F > 61 2 9275 7999
membership@finsia.com

QLD
T > 61 7 3002 0700
F > 61 7 3002 0799
membership@finsia.com

SA and NT
Level 7, Qantas House
144 North Terrace
Adelaide SA 5000

VIC and TAS
Level 43, 80 Collins Street
Melbourne VIC 3000
T > 61 3 9666 1000
F > 61 3 9666 1099
membership@finsia.com

WA
Level 14, Governor
Stirling Tower
197 St Georges Terrace
Perth 6000 WA
T > 61 8 6188 7661
T > 61 8 6188 7662
F > 61 8 6188 7607
membership@finsia.com

New Zealand

Auckland
Level 12, AMP Centre
29 Custom Street West
Auckland NZ 1143
T > 64 9 909 7534
F > 64 9 909 7531
members.nz@finsia.com

Wellington
Level 6, Wakefield House
90 The Terrace
Wellington NZ 6143
T > 64 4 473 5069
F > 64 4 499 1990
members.nz@finsia.com

International
PO Box H99
Australia Square
NSW 1215 Australia
T > 61 2 9275 7900
F > 61 2 9275 7999
membership@finsia.com

finsia.com

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How Safe are Safe Withdrawal Rates in Retirement? An Australian Perspective

RESEARCH REPORT

First published March 2014
Published by: Finsia — Financial Services Institute of Australasia, Level 18, 1 Bligh Street, Sydney NSW 2000 Australia (ACN 066 027 389, ABN 96 066 027 389).

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About the authors
Michael E Drew, PhD, SF Fin is a Professor of Finance at Griffith University and Partner at Drew, Walk & Co.

Adam N Walk, PhD, SF Fin is a Research Fellow at Griffith University and Partner at Drew, Walk & Co.

We thank Luo Wang for excellent research assistance. We thank Samuel Bell SA Fin, Dr Robert Bianchi SF Fin and Troy Rieck SF Fin and participants at Finsia's Retirement Adequacy Roundtable (July 2013) for comments.

Suggested citation
Drew, M, and Walk, A, (2014), *How Safe are Safe Withdrawal Rates in Retirement? An Australian Perspective*, Finsia (Financial Services Institute of Australasia), Sydney.

Availability
This report is available on the Finsia website (www.finsia.com).

Further information and comments
Samuel Bell SA Fin — Manager, Policy

T > 61 2 9275 7953
E > s.bell@finsia.com

FOREWORD

Finsia began a research program in 2012 to identify the scope of the retirement adequacy challenge and investigate policy responses to improve the sustainability of retirement savings for all Australians.

The first stage of the research culminated in a landmark research report — *Sequencing Risk: A key challenge to creating sustainable retirement income.*

In *Sequencing Risk*, Professor Michael Drew SF Fin, Dr Anup Basu F Fin and Brett Doran examined the profound influence that the ordering or sequence of investment returns exerts on the sustainability of retirement income. Their findings, based on simulations from a century of historical investment returns, challenged the orthodoxy that it is the average return of investments that determines the quality of retirement outcomes.

Importantly, this first phase of research identified that sequencing risk is acute particularly during the period in which retirement savings are at their peak.

In this second phase of research, Finsia furthers our understanding of what is now known as the 'Retirement Risk Zone' — the critical years that incorporate the final 20 years of the retirement saving journey and the first 15 years retirement. The retirement risk zone marks the shift from accumulation to withdrawal or decumulation of retirement savings.

In this report, *How Safe Are Safe Withdrawal Rates in Retirement? An Australian Perspective*, Professor Michael Drew SF Fin and Dr Adam Walk SF Fin tackle the logical next step by examining the post-retirement or decumulation phase in one's retirement journey.

The authors surveyed the annualised performance of different investments in a number of countries over a period of 112 years. From this, they calculated the portfolio success rates of different asset allocations considering different withdrawal rates. This research ultimately identifies the maximum withdrawal rate that ensures portfolio survivability based on long-term, historical averages.

It shows that the long-held convention that adequacy and sustainability of savings is assured by a 4 per cent withdrawal rate — the 4% Rule — is not a silver bullet.

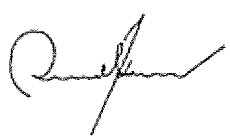
In fact, even with the exceptional performance of the Australian stock market over the last century, a 4 per cent withdrawal rate over 30 years on a 50:50 growth/defensive asset allocation is associated with a 20 per cent chance of financial ruin.

The implications of this research paper are two-fold. First, the financial services industry has an obligation to confront retirement sustainability and develop financial products that assist in mitigating longevity risk. This also includes industry practitioners carefully educating clients about retirement adequacy and sustainable withdrawal rates.

While the 4% Rule is a baseline, we need to move from a silver bullet approach to one that takes greater care in coordinating asset allocation, planning horizon, scenario testing and risk management to alleviate the asset-liability mismatch in retirement.

Second, it is clear that many Australian retirees will fall back on the pension faster than anticipated. That is, their lifetime of savings will not give them a lifetime of income. This creates a significant public policy dilemma and places a sizeable impost on the next generation to fund the future pension liabilities of their forebears.

Australia's system of compulsory superannuation is world-leading. With 20 years having passed since the introduction of the superannuation guarantee, now is the time to ensure that the industry is equipped to manage the adequacy challenge. The findings in this research paper form the foundation for this discussion.



Russell Thomas F Fin
CEO and Managing Director
Finsia

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HOW SAFE ARE SAFE WITHDRAWAL RATES IN RETIREMENT?

This study considers one of the cornerstone questions in the retirement income debate; namely, what's a safe withdrawal rate for retirement?

This question is of particular importance to Australia's superannuation system, which is characterised by having compulsory contributions during the retirement saving (or accumulation) phase, but no requirement to annuitise lump sums at the commencement of the retirement income (or distribution/decumulation) phase. As a result, many retirees face a classic asset-liability mismatch — the need to fund relatively short- and medium-term retirement spending needs with a longer term investment strategy. The Global Financial Crisis (GFC) provided a living case study of the perils of retirees ignoring the mismatch between the durations of retirement assets and liabilities.

Given the centrality of this question to the development of a sustainable retirement income strategy (both here and abroad), we wanted to commence our search using a tool that many individual (or mum and dad) investors may use when considering this question; that is, Google.

A simple Google search of the terms [safe withdrawal rate retirement] returned in excess of 5.2 million hits.[1]

Reviewing the first dozen pages of results, two key (yet contradictory) themes emerged:

1. The 4% or Golden Rule of Retirement Withdrawals;[2] and

2. The 4% Rule for Retirement Withdrawals Is Golden No More.[3]

The issue of what a safe withdrawal rate is remains one of the most hotly contested ideas in retirement planning today. The current debate challenges the decades-held view that there is a simple, robust solution to the asset-liability mismatch faced by many retirees.

The much celebrated 4% Rule has become a popular heuristic that has provided a quick shortcut to 'solving' this most difficult of retirement planning problems.[4] Using a 30-year holding period, William Bengen (1994) calculated that a 4.1 per cent withdrawal rate would allow the retiree to survive the worst market declines, hence the rise of the 4% Rule.

> *Assuming a minimum requirement of 30 years of portfolio longevity, a first-year withdrawal of 4 per cent, followed by inflation-adjusted withdrawals in subsequent years, should be safe.*
>
> *Bengen (1994) p. 172*

The results of our Google search mirror the current state of published research in the field, with recent studies suggesting that a safe withdrawal rate could range between less than two and as much as seven per cent of assets.[5] By any measure, this is an extraordinary range of results — imagine on a starting balance of $800,000, the lower bound (2 per cent) would not replace the current public pension for a couple, with the upper (7 per cent) bound equivalent to the current Association of Superannuation Funds of Australia (ASFA) comfortable standard of retirement income for a couple for a horizon of three decades.[6]

This study tests some of the most popular heuristics that have arisen from the safe withdrawal debate.

1 A Google search of [safe withdrawal rate retirement] returned 'about 5,280,000 results (0.18 seconds)' <http://www.google.com.au> (accessed 1 October 2013).

2 The rule that if retirees withdraw 4 per cent of their retirement assets every year, adjusted for inflation, their nest egg should last 30 years, is popularly termed the Golden or 4% Rule, see: Nasdaq Investor's Business Daily, 'How to use the 4% Rule for Retirement Withdrawals', (9 August 2013) <http://www.nasdaq.com/article/how-to-use-the-4-rule-for-retirement-withdrawals-cm266340>.

3 For further discussion, see: Eilene Zimmerman, '4% Rule for Retirement Withdrawals Is Golden No More', *New York Times*, (14 May 2013) <http://www.nytimes.com/2013/05/15/business/retirementspecial/the-4-rule-for-retirement-withdrawals-may-be-outdated.html?_r=0>.

4 The seminal study of Bengen (1994) considered safe withdrawal rate for a US investor using year-on-year returns from 1925 for a 50/50 stock/bond portfolio. Bengen (1994) assumed half the portfolio was allocated to the S&P 500 and half in intermediate term government bonds.

5 For an excellent summary of the current debate, see 'Is the 4% Rule Still Viable?' by Glenn Ruffenach (7 February 2013) in the Smart Money magazine of the *Wall Street Journal*. Ruffenach notes, 'Last year, a research paper in the Journal of Financial Planning predicted that a safe nest egg withdrawal rate for retirements begun in 2010 is 1.8%. Within weeks of that report's appearance, a study in Retirement Management Journal made the case that a safe withdrawal rate for some individuals could be as much as 7%.'

6 As at the June quarter 2013, the ASFA Retirement Standard suggests, in general, a couple looking to achieve a comfortable retirement needs to spend $56,406 a year, see: <http://www.superannuation.asn.au/resources/retirement-standard>.

The study finds the there is one key 'known unknown' in the debate — the ordering, sequencing or path dependency of returns (Basu, Doran and Drew, 2012, 2013; Doran, Drew and Walk, 2012; Bianchi, Drew and Walk, 2013). The Australian experience of returns has been among the best in the world over the last century. However, despite this stellar performance, serious questions are raised about the efficacy of the 4% Rule. To provide further support to this claim we explore the 4% Rule in a number of markets around the world to highlight how different returns paths can impact on the sustainability of a retirement income plan that is funded by drawing on capital and income returns in retirement.

The remainder of the report proceeds as follows. In the following section, we lay the ground work of the Retirement Risk Zone, and illustrate the key elements of the retirement income challenge.[7] From this foundational discussion, a formal survey of the key studies in the safe withdrawal rate literature is conducted. This assessment of previous studies highlights the US-centric nature of previous work, and provides a rationale for the methodological approach taken in this study.

The empirical section of the research, somewhat cheekily entitled, 'Why Australia may be the worst case study for safe withdrawal rates', places the Australian experience in an international context to provide further rigour to our testing of the 4% Rule. The rationale for our boldness in selecting this title (and subsequent broader international testing of the rule) is that Australia has had the best performing stock market in the world (in a sample covering 19 countries over a period of 112 years, ended 2011). The use of international comparators raises some serious issues for the robustness (or otherwise) of the 4% Rule. However, while acknowledging the shortcomings of the Rule, we argue that its best application may be to assist in informing baseline expectations of retirement income using paths of returns that in the future may not be as stellar as those from the land Down Under.

With a set of baseline results developed, we explore a range of starting balances (or retirement nest eggs) to test the sustainability of retirement income streams against some well-regarded comparators. We conclude the paper by considering next steps in the field of retirement income planning and possible avenues for future research.

7 For further discussion, see Finsia's Retirement Risk Zone website: <http://www.retirementriskzone.com.au>.

A PRIMER ON THE RETIREMENT RISK ZONE

The superannuation journey extends over much of the life course, from a person's working life through to retirement. The retirement risk zone (hereafter referred to as 'RRZ') represents the critical years that incorporate the last two decades of our retirement saving journey (commonly referred to as the accumulation phase) and the first fifteen years of our retirement years (termed the withdrawal, distribution, income or decumulation phase). It is this conversion period when many of the key risks that determine the sustainability (or otherwise) of our retirement income are at their most threatening. In short, what happens when the largest amount of our retirement savings is at risk, matters.

The following primer on the RRZ provides the foundation for the rest of this study. One of the central messages from this section is that, prior to assessing the efficacy of safe withdrawal rates in retirement, our ability to manage (and possibly mitigate) longevity risk in retirement can be eroded dramatically by the sequence of returns we experience when our retirement savings are at their zenith (Basu and Drew, 2009).

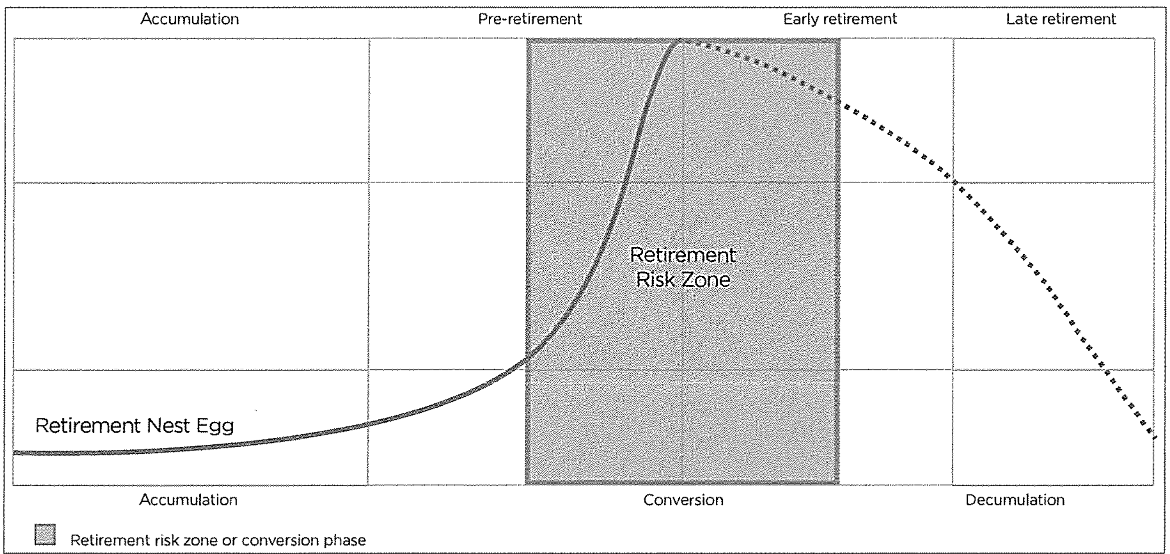
Since the decline of defined benefit (DB) plans, and the associated rise in defined contribution (DC) plans, retirement products have tended to focus mostly on the accumulation phase of the investment lifecycle, which begins on entry to the workforce and continues until retirement. In this phase, contributions and investment returns combine to generate the final plan balance, which is available for lump sum payout (largely the Australian experience) or the purchase of a pension or annuity product.

As more and more people from the baby boomer generation move into retirement, a raft of new changes are taking place in the global retirement planning industry. The turbulence experienced during the GFC has motivated regulatory action to examine flaws in DC plan design, and led trustees to seek better tools to assist their members in meeting long-term saving and income goals. As large numbers of investors have now met (or are soon to reach) their retirement date, stakeholders are considering whether existing asset accumulation products, tools and processes are likely to be adequate for providing income generation and protection into the future.

Consider an investor with a traditional 40-year accumulation period. Assume that the member is following the hopeful accumulation strategy of a 70 per cent stocks/25 per cent bonds/5 per cent cash asset allocation. Assuming a fixed rate of compounding, the member would experience around half of the dollar accumulation in the last decade of that 40-year period. Therefore, as the investor comes close enough to retirement, they have half of their dollar wealth at stake. At that point, trying to maximise total returns with naked exposure to the full volatility of the stock market, which may be defensible during the accumulation phase, may no longer make as much sense. At that point in the RRZ (or conversion phase) the issue of sequencing risk becomes vital for investors.[8]

Prudent management during the RRZ — shown pictorially in Figure 1 — also requires consideration of the early periods of retirement to secure retirement income across the decumulation phase. As with the final decade prior to retirement, the impact of the portfolio size effect immediately post retirement is critical in determining the sustainability of retirement income.

Figure 1: The retirement risk zone



8 The impact of this effect, popularly termed the 'portfolio size effect', was investigated by Basu and Drew (2009a), and subsequently considered for default designs (Basu and Drew, 2010) and retirement outcomes by gender (Basu and Drew, 2009b).

As Milevsky (2006), Milevsky and Abaimova (2006), Basu, Doran and Drew (2012, 2013) and Bianchi, Drew and Walk (2013) have illustrated, the odds of portfolio ruin in retirement are highly sensitive to the returns the investor earns decade by decade. Path dependency matters greatly. As a conditional probability statement, the experience of zero returns (let alone negative returns) in the first decade in retirement may be associated with a 70 to 80 per cent chance of portfolio ruin (that is, running out of money before the retiree dies).

Therefore, there is a transition phase before and immediately after retirement when return maximisation and risk taking may be considerably less desirable than downside protection for many investors. After that conversion phase, in late retirement, some retirees may need to focus on income distribution and, potentially, mortality credits.[9]

The RRZ — which includes the retirement date — is thus a critically important part of the investment lifecycle. It is during this phase that the best opportunity for improving retirement outcomes exists because, paradoxically, so much is at stake. Unfortunately, it is at this time when the risks to retirement objectives are at their most threatening.

One of the greatest challenges for retirees in Australia relates to the management of their retirement income (liability). While there are numerous approaches to the way in which members can convert retirement savings into retirement income, the majority can be categorised into three basic approaches. An excellent summary of these major approaches is provided by Schaus (2010), illustrated in Table 1.

The approaches to the conversion phase identified by Schaus (2010, Table 1) provide the perfect framework in which to place the research agenda undertaken in this study. This study considers the efficacy of safe withdrawal rates or, using Schaus's (2010) terminology, systematic withdrawal plans. It is interesting to note that Schaus (2010) confirms the industry norms of around 4 to 5 per cent per annum as a systematic withdrawal level (as well as highlighting the longevity risks associated with these norms).

9 In an annuity pool, the surviving annuitants receive some of the funds of the pool members who die earlier; this excess return is the 'mortality credit', and assists in the hedging of longevity risk.

Table 1 Major approaches to the conversion phase		
Approach	**Synopsis**	**Discussion**
Income-only plan	Those members with sufficient wealth may manage their assets so that they can live off the income from those assets without spending the principal.	– This plan may include income from bonds, such as treasury inflation protected securities (TIPS) or nominal bonds in pre-tax accounts. – It may also include term deposits and savings accounts. – In addition, participants might consider laddering certificates of deposit or look to stock holdings for dividend income. – Purchasing real estate can also provide rental or other income.
Systemic (or partial) withdrawal plans (SWPs)	Most retirees lack sufficient assets to live solely off the income generated by those assets. Rather, they will need to begin drawing down principal in addition to investment income.	– There are several ways to set up a SWP, such as withdrawing a fixed-dollar amount adjusted for inflation, taking a required minimum distribution amount that increases the percentage of assets withdrawn as the participant ages, or setting up a retirement bucket approach that earmarks certain assets to meet specific expenses. – Many industry participants who advocate a SWP approach suggest that retirees draw down no more than 4 to 5 per cent of their retirement assets each year. Yet, even at this withdrawal rate, many members run the risk of running out of money too quickly.
Guaranteed income/ annuitisation	Those with a lower risk tolerance or a greater expectation of longevity may want to convert a portion of their DC assets into an immediate or other type of income-producing annuity.	– By annuitising, retirees create an income stream that provides a monthly payout for the remainder of their lives. – Many types of annuities are being introduced within DC plans, including immediate, deferred fixed income, living benefit, and longevity insurance.

Source: Schaus (2010)

As retirees have no (or minimal) future income from their labour, income replacement (from retirement savings and/or the public pension) may have to last as long as 25 years, possibly more, particularly in the case of a couple. According to the Australian Life Tables (Commonwealth of Australia, 2009) an Australian male who lives until age 65 has approximately a 82 per cent chance of living beyond 85 and a 71 per cent chance of living past 90. Females are even longer-lived. And for couples who live to 65, there's a 90 per cent chance that one or both will live until beyond 92 and an 81 per cent chance that one or both will live beyond 97.

Faced with this longevity profile, retirees require solutions that sufficiently manage market risk, longevity risk, and inflation risk. However, as is a recurrent theme throughout the paper, it is important to note that the most important types of retirement risk (market, longevity and inflation risks) will change over the investor's life span. One of the potential advantages of robust retirement income planning is that these dynamic risks (and their respective emphasis) can be better managed through time, informed by the retiree's preferred outcome.

With the foundational aspects of the RRZ established, and the major approaches to the conversion phase outlined, we move the discussion in the following section to a critical review of the literature on safe withdrawal rates in retirement. In our opening remarks of this study, we noted the controversy online on the issue of safe withdrawal rates in retirement. As will be seen in the following section, the same debate rages throughout the scholarly literature on the topic.

In countries such as Australia where there is no single mandated approach to the retirement income conversion phase (that is, a range of income-only plans, systemic (or partial) withdrawal plans and/or guaranteed income/annuitisation plans), the risk of asset-liability mismatch abounds. Many retirees are faced with the challenge of funding relatively short- and medium-term (typically stable) retirement spending needs with a longer term (typically volatile) investment strategy. The complexities of liability-driven investing, even for seasoned investment professionals, can be challenging. The behavioural finance literature confirms the importance of rules-of-thumb (or heuristics) in financial decision making. And so it is with retirement income, with the 4% Rule being the 'rule-of-thumb' answer to the perennial question: 'How much money can I withdraw annually from my retirement nest egg without running out?'

The pioneering work in the field was contributed by Bengen (1994). Using historical simulation, the study shows that the retirement portfolios of people who retired during the period 1926 through 1976 and withdrew 4 per cent of the initial balanced portfolio value every year (adjusted for inflation) could be sustained for at least three decades. In a series of subsequent studies, Bengen (1996 (phase-down approach); 1997 (small capitalisation stocks in the asset allocation); 2001 (modified prosperous retirement, fixed-percentage withdrawals and floor-and-ceiling withdrawals); and 2006 (bespoke to client needs)) reports results that largely support the 4% Rule.

The second group of studies that provide support to the 4% Rule are known as the Trinity studies.[10] These studies use a simple, but highly informative, approach to investigate withdrawal rates with respect to different asset allocations, and several time horizons. Cooley, Hubbard, and Walz (1998) measure the portfolio success rate of various portfolios over 15, 20, 25, and 30 years from 1926 through 1995. The portfolio success rate is the percentage of times a retiree could sustain a given withdrawal rate without exhausting the retirement assets. The findings demonstrate that the optimal portfolio should consist of around 75 per cent in stocks and 25 per cent in bonds (75:25). Furthermore, a typical retiree that has an asset allocation of 50:50 (with a 30-year retirement horizon) could sustain a 3 per cent withdrawal rate with complete success, and a 4 per cent withdrawal rate with a probability of portfolio success of 95 per cent. Cooley, Hubbard, and Walz (1999) update their previous work by assuming monthly withdrawals of retirement income and monthly accruals of portfolio returns. The results using monthly data largely corroborate (if not slightly improve) their substantive findings on safe withdrawal rates.[11] Finally, in their most recent paper, Cooley, Hubbard, and Walz (2011) extend their observation period from January 1926 through December 2009. This study suggests that retirees who plan to make annual inflation adjusted withdrawals should stay within the 4 to 5 per cent range.[12]

The sequence of major events in the first decade of the 21st century — 9/11; the dot.com bubble; the sub-prime crisis and the GFC — have resulted in a level of wealth compression in investment portfolios not seen for many years.

The sequence of major events in the first decade of the 21st century — 9/11; the dot.com bubble; the sub-prime crisis and the GFC — have resulted in a level of wealth compression in investment portfolios not seen for many years.

This period of heightened volatility underscored the importance of path dependency to the sustainability of retirement income. It has given rise to a far more critical assessment of the 4% Rule (and its variants). However, as will be canvassed in the following discussion, much of the work still remains US-centric and lacks international perspective.

10 All three authors are professors of finance at Trinity University in San Antonio, Texas.

11 Cooley, Hubbard, and Walz (2003) also investigate portfolio success rates for various withdrawal rates with and without international stocks in the portfolio. Using Monte Carlo analysis, Pye (2000) also concludes that the 4 per cent, inflation-adjusted withdrawal rate is highly sustainable. Guyton (2004) and Guyton and Klinger (2006) provide further support to the 4% Rule by expanding the range of asset classes held by the retiree.

12 Cooley, Hubbard, and Walz (2011) note that for retirees who are willing to accept greater risk of portfolio ruin, portfolios with at least 50 per cent allocated to stocks can provide a withdrawals rates upwards of 7 per cent.

The work of Spitzer, Strieter, and Singh (2007) and Spitzer (2008) has been important in developing a line of argument that suggests the 4% Rule may be an oversimplification of a complex process that involves the analysis of risk tolerance, asset allocation, withdrawal size and expected returns. Using a bootstrap approach, these studies examine a myriad of withdrawal rates finding that the fixed 4% Rule is not always safe and that dynamic approaches to the withdrawal rate may assist the retiree. Harris (2009) finds that sequencing risk is a key determinant of the sustainability (or otherwise) of safe withdrawal rates, with rates varying in the range of 2 to 4 per cent.[13]

The work of Pfau (2011) highlights the importance of market valuations on the sustainability of safe withdrawal rates. Taking a novel multi-factor regression approach, Pfau (2011) shows that for a typical retiree in the US (with a 30-year retirement horizon) the maximum sustainable withdrawal rates (MWRs) peaked at 8.8 per cent for those retired in 1982, falling to around 1.5 per cent during the GFC in 2008. Finke, Pfau, and Williams (2012) explore optimal withdrawal rates and asset allocations for retirees with different attitudes toward shortfall risk. The study uses a bootstrap method to investigate withdrawal rates from 3 per cent through 9 per cent, and stock allocations between zero and 100 per cent. The findings suggest that the traditional 4% Rule and modest (30 per cent) stock allocation may only be appropriate for risk-averse retirees who must revert to living on social security income if the portfolio is exhausted.

Continuing the market valuation theme, Finke, Pfau, and Blanchett (2013) investigate the robustness of the 4% Rule when today's low interest rates reflect future expectation of bond returns within a retirement portfolio. Using a Monte Carlo simulation (6 per cent historical equity premium and -1.4 per cent average real bond returns on five-year tips), the findings demonstrate that failure rates are surprisingly sensitive to bond returns. With a zero per cent bond yield, the hypothetical retiree has a 33 per cent chance of running out of money, and with a real US bond yield of -1.4 per cent the odds that the retiree will run out of money are 57 per cent. Importantly, the researchers conclude that there is nothing inherently safe about the 4% Rule in the low interest rate environment that the US is currently experiencing.

Extensive research of 'safe' withdrawal rates in the US market has prompted critics to argue that the result may be distorted by survivorship bias or data snooping. Dimson, Marsh, and Staunton (2004) argue that only looking at past US data for future predictions will lead to 'success bias'. One way to dismiss data snooping bias is to conduct out-of-sample tests to confirm the findings from the original studies.

Pfau (2010) conducted the first major study to examine the issue of safe withdrawal rates from a larger selection of countries. This study replicates the methodology of Bengen (2006) by using the Dimson, Marsh, and Staunton data from 1900 through 2008 for 17 developed countries. The analysis provides some interesting results that the 4 per cent withdrawal rate is not safe when using the original Bengen (2006) maximum safe withdrawal rate criterion. Pfau (2010) implements a 'perfect foresight assumption' to test safe withdrawal rates around the world (that is, it is assumed that in each year for each country the new retiree has perfect foresight to choose the fixed asset allocation for the subsequent 30 years that provides the best MWR). The findings show that, even with the assumption of perfect foresight, the maximum safe withdrawal rate exceeds 4 per cent in only four of the 17 countries, ranges between 2 and 4 per cent in a further eight countries, and is less than 2 per cent in five countries. The most unfortunate retirees in Pfau's (2010) analysis were those investors retiring in 1940 in Japan, with a maximum withdrawal rate of only 0.47 per cent per annum.[14]

Even with the assumption of perfect foresight, maximum safe withdrawal rate exceeds 4 per cent in only four of the 17 countries.

13 Athavale and Goebal (2011) examine withdrawal rates over a 35-year retirement horizon (with varying assumptions for the underlying distribution of portfolio returns) and find that a 2.5 per cent withdrawal rate could be sustained over a 35-year period. Zolt (2013) again illustrates the importance of a dynamic approach to withdrawal rates, looking at the impact of foregoing annual inflation increases on withdrawal rates when cumulative portfolio performance is less than expected.

14 A further interesting study on the international experience, particularly the experience in emerging markets, was conducted by Meng and Pfau (2011) who investigated the robustness of the 4% Rule in 25 emerging markets through to the end of 2009. Due to the limited historical data for emerging markets, this study uses a simulation approach and again invokes the perfect foresight assumption. The findings demonstrate that the 4% Rule is perhaps not as safe as previously thought. Only six out of 25 countries could sustain 30 years of withdrawals with a 4 per cent withdrawal rate, 11 countries experienced withdrawal rates between 2 and 4 per cent, and eight countries experienced withdrawal rates of less than 2 per cent. The worst-case scenario was experienced in Russia.

We are motivated in this study to build on the findings commencing with Bengen (1994) through to the current agenda investigated by Pfau (2010). Much of the work to date, with the exception of Pfau (2010) and Meng and Pfau (2011), has centred on the US experience (with the vast majority of studies using Ibbotson Associates' Stocks, Bonds, Bills, and Inflation (SBBI) data from 1926). Moreover, many studies, even when using various simulation techniques (such as Monte Carlo and/or bootstrap simulation) are sampling from portfolios largely exposed to US capital markets. The recent findings of Pfau (2010) are instructive in that, even when invoking the assumption of perfect foresight, the defensibility of blindly following the 4% Rule is limited.

While acknowledging Pfau's (2010) motivation to use the perfect foresight assumption in testing the 4% Rule (that is, 'this assumption avoids the accusations that a poor-performing asset allocation was chosen to discredit the 4 per cent rule [p.54]'), this study will use a range of popular asset allocation choices in the retirement income phase to test the 4% Rule. This methodological decision is supported by Pfau (2010) who states, 'consider a specific asset allocation of 50:50 for stocks and bonds ... [and] a 4 per cent withdrawal rate when using the SAFEMAX (that is, safe maximum withdrawal rate) criterion for any country in the DMS data [p.60].' Our study begins where Pfau's (2010) important international contribution concludes. Using a range of asset allocations, and widely different return experiences and investment horizons, we ask: What's a safe withdrawal rate for retirement?

In order to provide positive insights into what is, at its core, a normative question, our review of the literature suggests that it is prudent for researchers to investigate capital markets that have very, very long historical data series and, if possible, markets with different return distributions. For this reason, we have non-randomly selected five countries to stress test the 4% Rule. As will be discussed in the following section, all 19 countries in the Dimson, Marsh and Staunton (2012) database are ranked in ascending order based on their respective annualised performance (real accumulated returns) of stock returns for the period 1900 through 2011 (a total of 112 years). Those countries representing the key percentile levels (minimum; first quartile; median; third quartile and maximum) are selected to test safe withdrawal rates under different asset allocations and investment horizons.

'Consider a specific asset allocation of 50:50 for stocks and bonds ... [and] a 4 per cent withdrawal rate when using the SAFEMAX (that is, safe maximum withdrawal rate) criterion for any country in the DMS data.'

Pfau (2010) p. 60

Given the centrality of inflation (and its relationship to stocks, bonds and bills through time), we use real returns throughout the study. Specifically, instead of using nominal rates of return and then adjusting withdrawals each year for inflation, we elect to use real returns to avoid the annual inflation adjustment. Annual withdrawal rates ranging from 1 per cent through 10 per cent (in increments of 100 basis points) are considered across investment horizons of 10, 20, 30, and 40 years. Given that Australians are living longer lives (and many Australians retire before 65 years of age), we argue it is important to include the 30- and 40-year horizons to provide positive insights into the robustness of safe withdrawal rates across longer horizons. We consider the 4% Rule for stock allocations ranging from zero to 100 per cent (in increments of 25 per cent) for each of our representative countries (rebalanced annually), and report maximum safe withdrawal rates (or SAFEMAX as in Bengen (2005)).[15] Finally, we assume that retirees make an initial withdrawal at the commencement of each year. That is, the initial withdrawal amount is equal to the specified withdrawal rate times the starting balance of the portfolio (Pfau, 2012).

With our research agenda informed and motivated by the body of work that has considered the controversial topic of safe withdrawal rates in retirement, let's recall the late Professor Julius Sumner Miller's (1909–1987) oft-quoted epithet, 'Why is it so?'

15 We examine safe withdrawal rates for five countries for the period 1900 through 2011. The long horizon nature of the DMS (2012) database allows for a range of overlapping retirement periods to be examined (specifically, 102 x 10 years; 92 x 20 years; 82 x 30 years; and 72 x 40 years) across varying asset allocations to stocks, bonds and bills for each country.

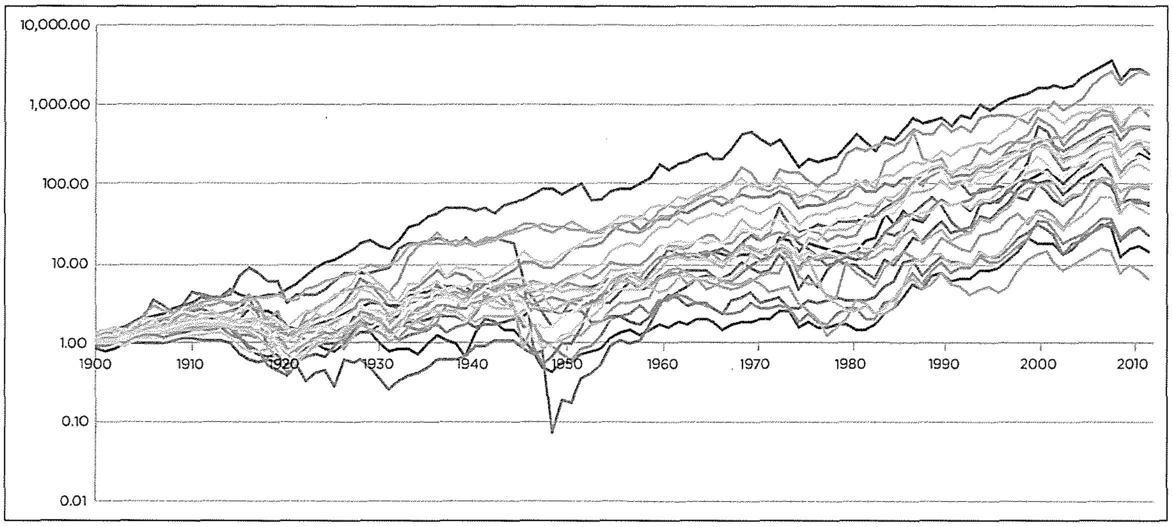
WHY AUSTRALIA MAY BE THE WORST CASE STUDY FOR SAFE WITHDRAWAL RATES

The empirical section of the study is titled, 'Why Australia may be the worst case study for safe withdrawal rates.' It is important to provide a clear rationale for this decision. As we have seen from the survey of the literature, previous studies have highlighted the importance of scenario testing in safe withdrawal rate studies. Moreover, the literature has stressed the potential dangers of the US-centric nature of the testing, particularly given the strong performance of the US stocks over many decades.

To directly address this concern, we use the Dimson, Marsh and Staunton (DMS) (2002, 2012) database, covering 19 countries (and three regions: world, world ex-US, and Europe), all with index series that start in 1900 through 2011.[16] Figure 2 provides the annualised performance of $1 invested in stocks in all 19 countries and three regions using real accumulated returns.

It is important to note that these results are plotted using a logarithmic scale on the y-axis, with a maximum dollar value of $2,459 (Australia) through to a minimum of $6 in Italy. To provide a sense of the annualised (or geometric) reward and risk of these different markets; Table 2 provides an historical, returns-based ranking in ascending order.

Figure 2 Evolution of $1 invested in 1900 (n=22, logarithmic scale base=10)



16 As noted by Dimson, Marsh and Stauton (2012), the database contains annual returns on stocks, bonds, bills, inflation, and currencies for 19 countries from 1900 to 2011. The countries comprise two North American nations (Canada and the USA), eight euro-currency area states (Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, and Spain), five European markets that are outside the euro area (Denmark, Norway, Sweden, Switzerland, and the UK), three Asia-Pacific countries (Australia, Japan, and New Zealand), and one African market (South Africa). These countries covered 89 per cent of the global stock market in 1900, and 85 per cent of its market capitalisation by the start of 2012.

Table 2 Ranking of annualised performance (stocks, real accumulated returns)				
Ranking	Country	Annualised performance (%)	Standard deviation	Reward/risk ratio
1	**Australia**	**7.22**	**18.23**	**0.40**
2	South Africa	7.21	22.49	0.32
3	United States	6.19	20.20	0.31
4	Sweden	6.11	22.87	0.27
5	**New Zealand**	**5.76**	**19.66**	**0.29**
6	Canada	5.69	17.22	0.33
7	United Kingdom	5.20	19.94	0.26
8	Finland	5.01	30.41	0.16
9	Denmark	4.85	20.90	0.23
10	**Netherlands**	**4.81**	**21.76**	**0.22**
11	Switzerland	4.13	19.73	0.21
12	Norway	4.08	27.33	0.15
13	Ireland	3.72	23.06	0.16
14	**Japan**	**3.62**	**29.78**	**0.12**
15	Spain	3.42	22.21	0.15
16	France	2.87	23.45	0.12
17	Germany	2.86	32.18	0.09
18	Belgium	2.39	23.57	0.10
19	**Italy**	**1.68**	**28.99**	**0.06**

Source: DMS (2012)

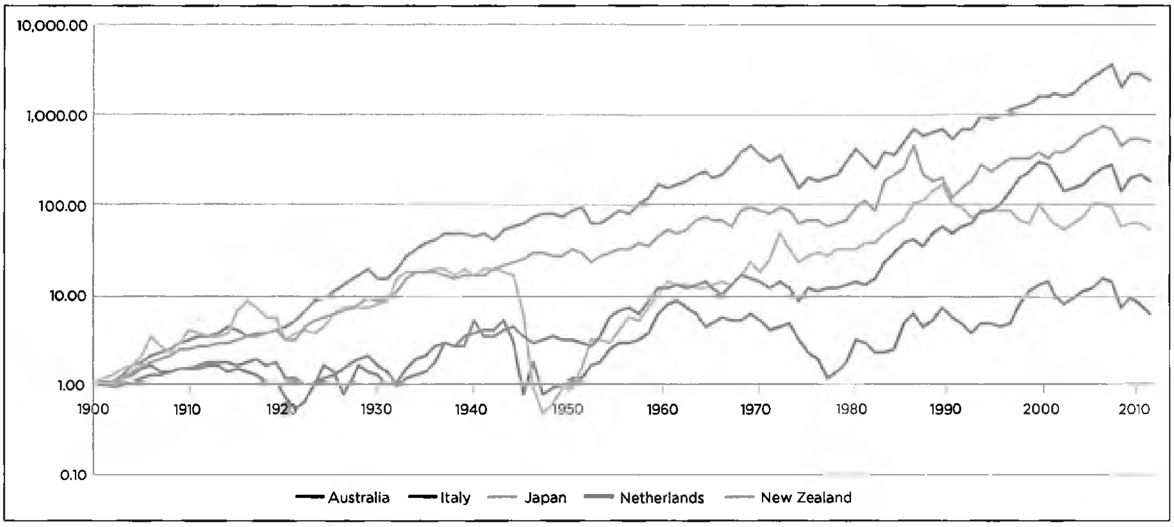
We have highlighted five countries — Australia (AUS); New Zealand (NZL); Netherlands (NLD); Japan (JPN); and Italy (ITA) — in the table as they represent annualised performance levels that most closely correspond to key percentiles in the distribution of the annualised performance of stock markets over the long run.[17]

Table 3 Distribution of annualised performance (stocks, real accumulated returns)		
Percentile	Annualised performance (%)	Representative country
Minimum value	1.68	Italy
First quartile (25th percentile)	3.52	Japan
Median (50th percentile)	4.81	Netherlands
Third quartile (75th percentile)	5.73	New Zealand
Maximum value	7.22	Australia

17 We use the standard three-letter country codes defined in ISO 3166-1 interchangeably throughout this study, part of the ISO 3166 standard published by the International Organization for Standardisation (ISO).

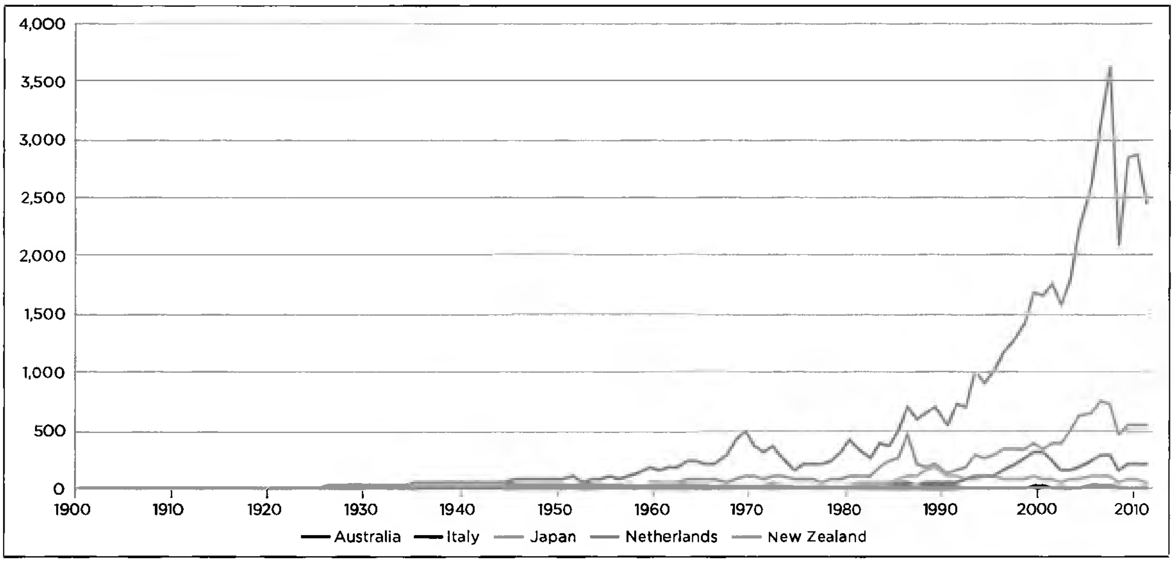
These results underscore the concerns of previous studies in the field regarding the need to select different scenarios, countries, return distributions, and sequences of returns when testing the 4% Rule. If we were to focus solely on Australia, we would run the risk of undertaking another safe withdrawal rate study, though this time outside the US, using a stock market that has been a very strong performer over the observation period. The accumulated performance of stocks in Australia over the last 112 years has been superior to the vast majority of other markets (given that the sample covers around 85 per cent of global market capitalisation in 2012), but, more importantly, has done so with the lowest level of recorded risk (where risk is defined as the standard deviation of returns). Hence, it is not surprising that the reward/risk ratio (shown in Table 2, column 5) is also superior to the rest of the world, nearly double that of the median market, and seven times that of the worst performing market. In fact, compared to Italy, Australia has recorded over four times the annualised performance with less than two-thirds the volatility. To ensure consistency, we now plot the five countries that approximate the key percentiles to highlight the distribution of investment outcomes.

Figure 3 Evolution of $1 invested in 1900 (n=5, logarithmic scale base=10)



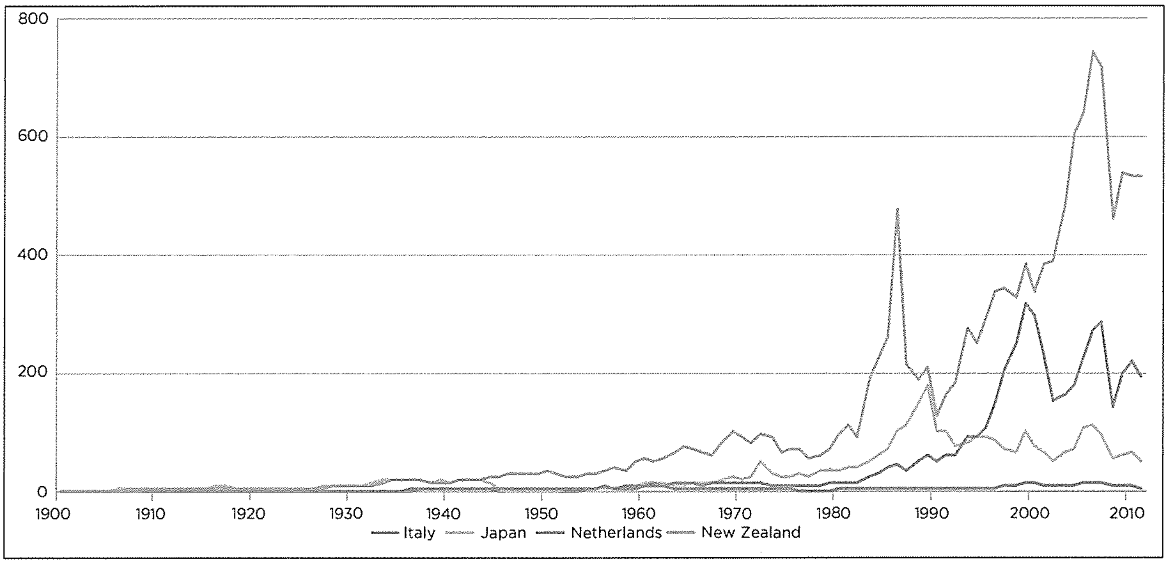
It is also instructive to now replace the logarithmic scale on the y-axis with a simple final value scale, to appreciate the differences in dollar outcomes for investors.

Figure 4 Evolution of $1 invested in 1900 (n=5, final value scale)



Finally, given the stellar performance of Australian stocks, we exclude the Australian series from the chart to better illustrate the lower four percentiles of interest.

Figure 5 Evolution of $1 invested in 1900 (n=4, ex-Australia, final value scale)



In summary, over the last 112 years (1900 through 2011), the real value of stocks, with income reinvested, grew to around $2,459 in Australia (max); $531 in New Zealand (Q3); $193 in the Netherlands (median); $53 in Japan (Q1); and $6 in Italy (min). Moreover, as a general (but controversial) observation, the standard deviation was typically higher for the countries in the lowest quartile of annualised performance, when compared to those in the top quartile (see Appendix).

We also report the annualised performance of accumulated bond returns in the DMS (2012) database. It is interesting to note that while many of the countries selected for analysis remain largely stable in the bond ranking, the changes in ranking historically for Australia is stark (from the best annualised performance in stocks to slightly above median in bonds).

Table 4 Ranking of annualised performance (bonds, real accumulated returns)				
Ranking	Country	Annualised performance (%)	Standard deviation	Reward/risk ratio
1	Denmark	3.18	11.69	0.27
2	Sweden	2.56	12.42	0.21
3	Canada	2.22	10.42	0.21
4	Switzerland	2.19	9.34	0.23
5	**New Zealand (#5 stocks)**	**2.12**	**9.11**	**0.23**
6	United States	2.01	10.34	0.19
7	Norway	1.82	12.17	0.15
8	South Africa	1.77	10.35	0.17
9	**Australia (#1 stocks)**	**1.57**	**13.20**	**0.12**
10	United Kingdom	1.52	13.75	0.11
11	**Netherlands (#10 stocks)**	**1.51**	**9.41**	**0.16**
12	Spain	1.31	11.71	0.11
13	Ireland	0.94	14.80	0.06
14	Belgium	-0.08	11.93	-0.01
15	France	-0.10	12.96	-0.01
16	Finland	-0.17	13.65	-0.01
17	**Japan (#14 stocks)**	**-1.06**	**20.02**	**-0.05**
18	**Italy (#19 stocks)**	**-1.74**	**14.02**	**-0.12**
19	Germany	-1.77	15.51	-0.11

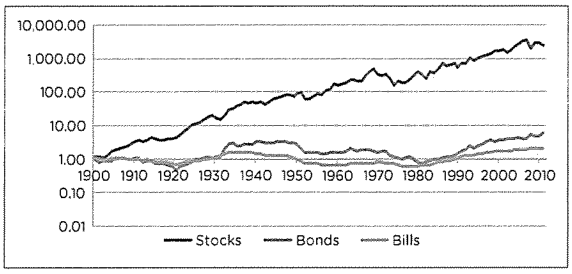
Source: DMS (2012)

We posit that the divergence of results globally provides a very wide range of scenarios under which to test the safe withdrawal rule (in addition to the potential risk of retirees' forming future expectations reliant on Australia's historical performance). We now present a visual comparison of the differing return histories of our non-random sample.[18] Following this comparison, we conduct tests of the 4% Rule across our five selected countries.

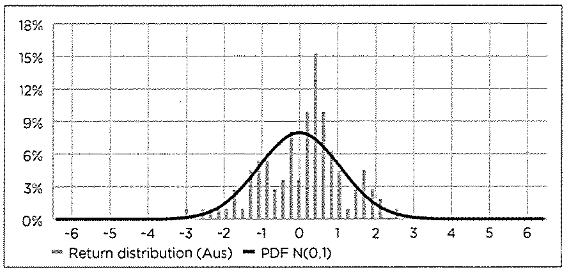
18 For list of summary statistics for all countries (inflation, stocks, bonds and bills) see Appendix.

Figure 6 Annualised performance of stocks, bonds and bills

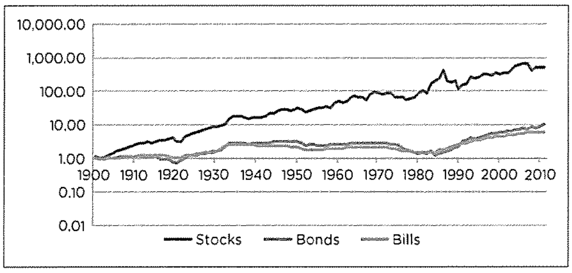
Australia (stocks 2,459; bonds 5.7; bills 2.2)



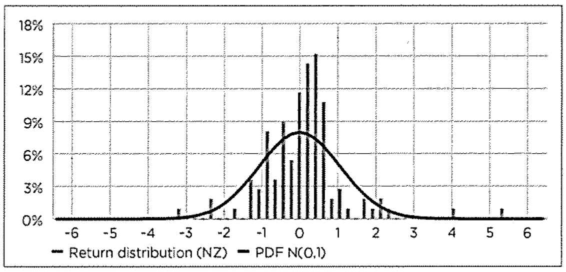
Australia histogram stocks N (7.22, 18.2)



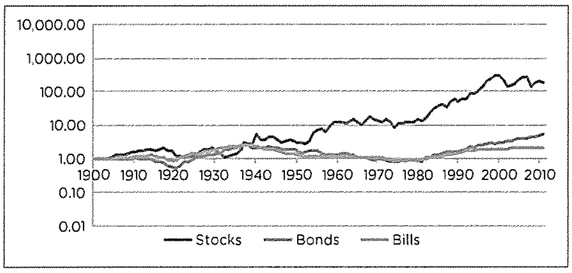
New Zealand (stocks 531; bonds 10.5; bills 6.4)



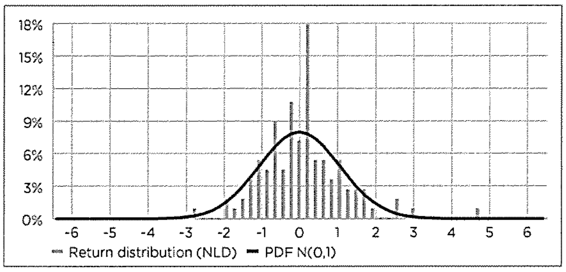
New Zealand histogram stocks N (5.76, 19.7)



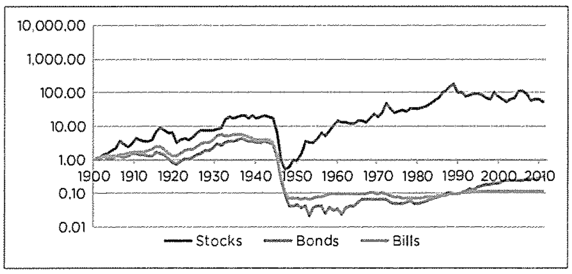
Netherlands (stocks 193; bonds 5.4; bills 2.1)



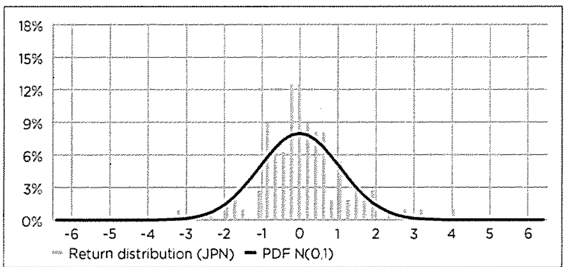
Netherlands histogram stocks N (4.81, 21.8)



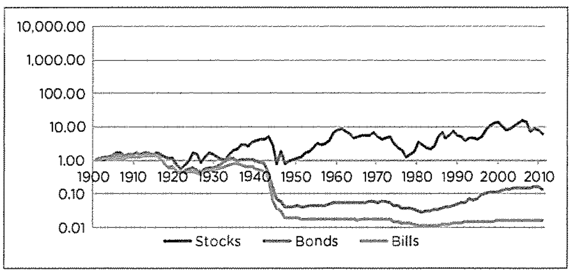
Japan (stocks 53; bonds 0.3; bills 0.1)



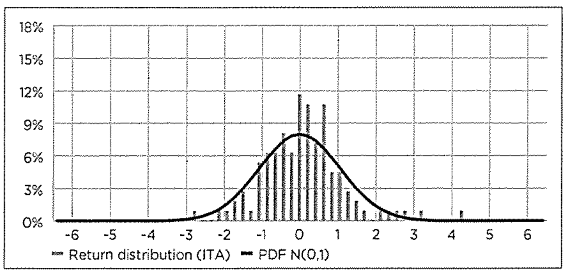
Japan histogram stocks N (3.62, 29.8)



Italy (stocks 6; bonds 0.14; bills 0.02)



Italy histogram stocks N (1.68, 29.0)



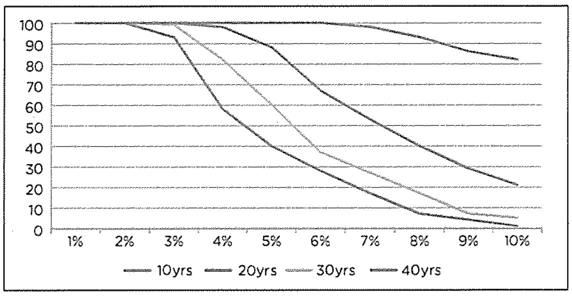
AUSTRALIA

Given the strong performance of Australian stocks over the last century (in concert with the average performance of bonds), those portfolios with greater allocations to growth assets have typically exhibited greater longevity. However, even with this stellar performance, we find success for the 4% Rule in the shortest of timeframes, with horizons greater than a decade exposing the hypothetical investor to some chance of ruin.

Table 5 Portfolio success rates

	Withdrawal rate as a percentage of initial portfolio value									
Payout	1%	2%	3%	**4%**	5%	6%	7%	8%	9%	10%
100% stocks										
10 yrs	100%	100%	100%	**100%**	100%	99%	96%	96%	95%	90%
20 yrs	100%	100%	100%	**98%**	96%	91%	76%	64%	51%	33%
30 yrs	100%	100%	99%	**96%**	90%	72%	61%	45%	27%	16%
40 yrs	100%	100%	97%	**94%**	79%	63%	50%	32%	21%	11%
75% stocks/20% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	99%	98%	95%	93%	87%
20 yrs	100%	100%	100%	**98%**	93%	85%	65%	52%	41%	24%
30 yrs	100%	100%	99%	**95%**	77%	61%	41%	27%	17%	9%
40 yrs	100%	100%	97%	**88%**	60%	50%	26%	18%	8%	4%
50% stocks/45% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	98%	93%	86%	82%
20 yrs	100%	100%	100%	**98%**	88%	67%	53%	40%	29%	21%
30 yrs	100%	100%	99%	**82%**	60%	37%	27%	17%	7%	5%
40 yrs	100%	100%	93%	**58%**	40%	28%	17%	7%	4%	1%
25% stocks/70% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	97%	89%	82%	76%
20 yrs	100%	100%	100%	**88%**	67%	51%	36%	30%	27%	18%
30 yrs	100%	100%	85%	**56%**	33%	28%	17%	10%	6%	2%
40 yrs	100%	94%	63%	**33%**	24%	11%	6%	3%	1%	0%
95% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	95%	92%	81%	71%	58%
20 yrs	100%	100%	93%	**67%**	48%	35%	29%	28%	26%	16%
30 yrs	100%	90%	49%	**33%**	26%	18%	10%	6%	2%	2%
40 yrs	100%	72%	32%	**24%**	8%	4%	1%	1%	0%	0%

Figure 7 Portfolio success rates comparison

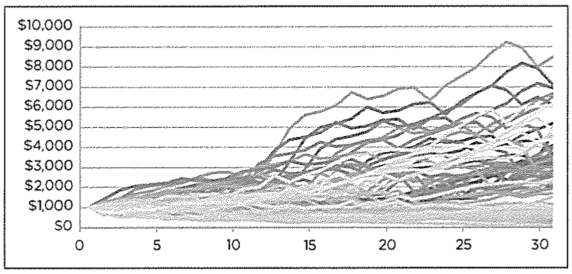


Turning specifically to the 30-year planning horizon, we report SAFEMAX results (that is, the maximum withdrawal rate that ensured portfolio survivability) for a range of risk preferences. Given its popularity in practice and supported by the literature, we focus on the 50:50 growth/defensive asset allocation. We find that, even with a 10 per cent chance of portfolio ruin, the SAFEMAX 90 stands at 3.62 per cent, some 40 basis points less than that suggested by the 4% Rule. In fact, in this scenario, a 4 per cent withdrawal rate was associated with a one-in-five chance of ruin.

Table 6 30-year SAFEMAX rates

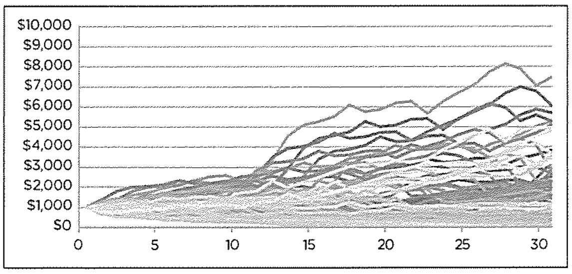
Asset allocation (rebalanced annually, 30 years)	Withdrawal rate as a percentage of initial portfolio value			
	SAFEMAX100	SAFEMAX95	SAFEMAX90	SAFEMAX50
100% stocks	2.74	4.20	5.13	7.63
75% stocks/20% bonds/5% bills	2.94	4.01	4.31	6.71
50% stocks/45% bonds/5% bills	**2.96**	**3.54**	**3.62**	**5.37**
25% stocks/70% bonds/5% bills	2.45	2.69	2.85	4.11
95% bonds/5% bills	1.66	1.83	2.04	5.37

Figure 8 SAFEMAX



SAFEMAX100 = 2.96%

Figure 9 4% Rule



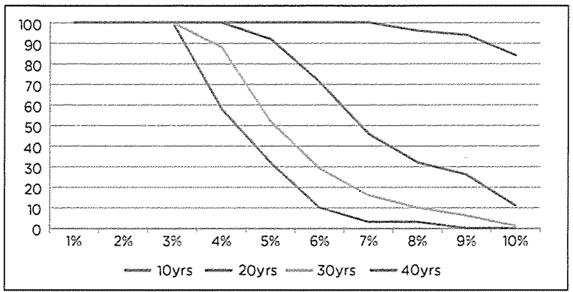
NEW ZEALAND

The combination of New Zealand's third quartile performance in both stocks and bonds over the last 112 years has provided the strongest support for the Golden Rule in this study. This is particularly the case with the 75:25 portfolio, recording a SAFEMAX100 of approximately 4 per cent in the 10- through 30-year horizons and around a one-in-ten chance of ruin over 40 years.

Table 7 Portfolio success rates

	Withdrawal rate as a percentage of initial portfolio value									
Payout	1%	2%	3%	**4%**	5%	6%	7%	8%	9%	10%
100% stocks										
10 yrs	100%	100%	100%	**100%**	99%	99%	99%	96%	94%	86%
20 yrs	100%	100%	99%	**99%**	98%	89%	71%	52%	32%	17%
30 yrs	100%	100%	100%	**100%**	87%	66%	48%	17%	9%	7%
40 yrs	100%	100%	100%	**99%**	71%	53%	19%	7%	3%	1%
75% stocks/20% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	99%	97%	93%	89%
20 yrs	100%	100%	100%	**100%**	98%	82%	62%	41%	23%	12%
30 yrs	100%	100%	100%	**99%**	74%	49%	26%	11%	9%	5%
40 yrs	100%	100%	100%	**88%**	57%	28%	6%	3%	1%	0%
50% stocks/45% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	100%	96%	94%	84%
20 yrs	100%	100%	100%	**100%**	92%	71%	46%	32%	26%	11%
30 yrs	100%	100%	100%	**88%**	52%	29%	16%	10%	6%	1%
40 yrs	100%	100%	100%	**58%**	32%	10%	3%	3%	0%	0%
25% stocks/70% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	100%	94%	90%	78%
20 yrs	100%	100%	100%	**97%**	82%	47%	36%	30%	17%	11%
30 yrs	100%	100%	100%	**52%**	28%	23%	11%	7%	1%	1%
40 yrs	100%	100%	72%	**40%**	17%	4%	3%	0%	0%	0%
95% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	96%	92%	79%	70%
20 yrs	100%	100%	100%	**87%**	53%	34%	32%	26%	12%	11%
30 yrs	100%	100%	68%	**33%**	24%	16%	5%	4%	1%	1%
40 yrs	100%	89%	46%	**21%**	7%	3%	0%	0%	0%	0%

Figure 10 Portfolio success rates comparison

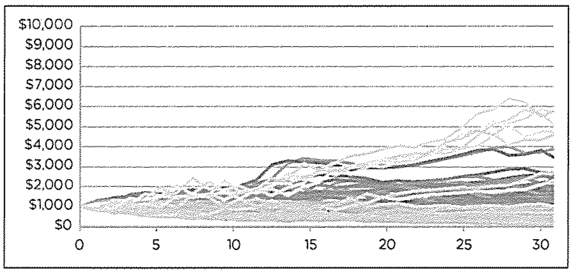


Turning to the 30-year horizon, New Zealand again recorded the highest SAFEMAX 100 level at 3.64 per cent, approaching the 4% Rule level of 4 per cent with a 10 per cent probability of portfolio ruin. The results again suggest that the real returns in more defensive assets (bonds and bills) need to be complemented with stocks to assist in asset-liability matching for retirees.

Table 8 30-year SAFEMAX rates

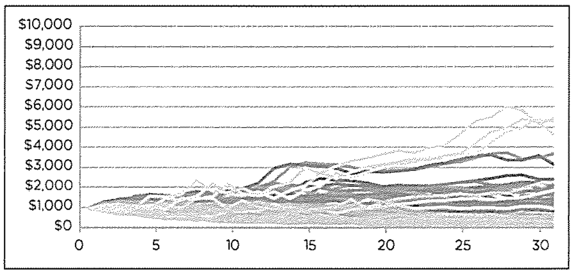
Asset allocation (rebalanced annually, 30 years)	Withdrawal rate as a percentage of initial portfolio value			
	SAFEMAX100	SAFEMAX95	SAFEMAX90	SAFEMAX50
100% stocks	4.05	4.68	4.95	6.82
75% stocks/20% bonds/5% bills	3.97	4.37	4.51	5.96
50% stocks/45% bonds/5% bills	**3.64**	**3.90**	**3.97**	**5.18**
25% stocks/70% bonds/5% bills	3.12	3.22	3.36	4.30
95% bonds/5% bills	2.39	2.44	2.51	3.36

Figure 11 SAFEMAX



SAFEMAX100 = 3.64%

Figure 12 4% Rule



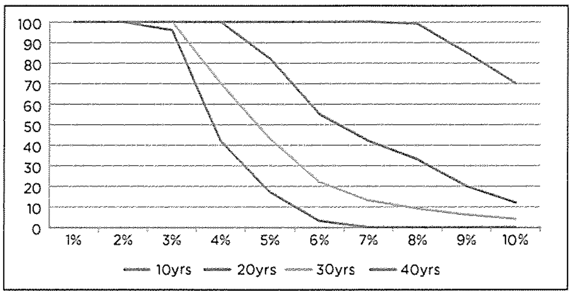
NETHERLANDS

We have selected the Netherlands as a proxy for testing the 4% Rule in a market that achieved about median annualised stock returns over the last 112 years. The results provide some support to the 4% Rule for horizons of around 20 years (particularly for those portfolios with a minimum of half the portfolio allocated to stocks). However, the sustainability of this practice is challenged over longer time periods.

Table 9 Portfolio success rates

	Withdrawal rate as a percentage of initial portfolio value									
Payout	1%	2%	3%	**4%**	5%	6%	7%	8%	9%	10%
100% stocks										
10 yrs	100%	100%	100%	**100%**	100%	100%	96%	88%	79%	69%
20 yrs	100%	100%	100%	**97%**	84%	63%	49%	37%	33%	26%
30 yrs	100%	100%	99%	**79%**	56%	35%	24%	20%	18%	11%
40 yrs	100%	100%	86%	**61%**	39%	22%	13%	10%	4%	1%
75% stocks/20% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	100%	95%	85%	69%
20 yrs	100%	100%	100%	**100%**	83%	65%	47%	34%	28%	20%
30 yrs	100%	100%	100%	**78%**	49%	33%	20%	12%	9%	6%
40 yrs	100%	100%	99%	**56%**	31%	13%	3%	0%	0%	0%
50% stocks/45% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	100%	99%	85%	70%
20 yrs	100%	100%	100%	**100%**	82%	55%	42%	33%	20%	12%
30 yrs	100%	100%	100%	**70%**	43%	22%	13%	9%	6%	4%
40 yrs	100%	100%	96%	**42%**	17%	3%	0%	0%	0%	0%
25% stocks/70% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	100%	98%	82%	65%
20 yrs	100%	100%	100%	**99%**	63%	45%	36%	26%	14%	5%
30 yrs	100%	100%	94%	**46%**	29%	20%	11%	6%	2%	2%
40 yrs	100%	100%	65%	**24%**	10%	3%	1%	0%	0%	0%
95% bonds/5% bills										
10 yrs	100%	100%	100%	**100%**	100%	100%	100%	94%	66%	54%
20 yrs	100%	100%	100%	**75%**	46%	37%	33%	20%	5%	4%
30 yrs	100%	100%	62%	**35%**	23%	15%	7%	2%	2%	1%
40 yrs	100%	68%	35%	**11%**	6%	3%	1%	0%	0%	0%

Figure 13 Portfolio success rates comparison

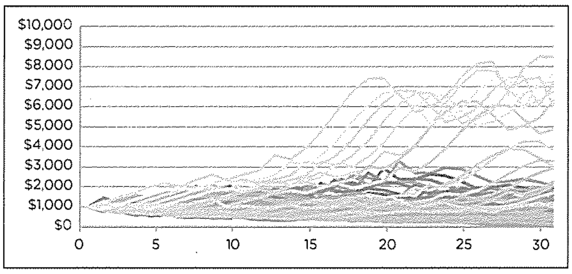


The Netherlands case study suggests more a 3% Rule, or 3.5% Rule if retirees are willing to take on some risk of ruin. The 4% Rule particularly is challenged with a 25% stocks/70% bonds/5% bills allocation (25:75), with the chance of the portfolio sustaining more than 30 years of income less than the probability of tossing a head on a fair coin.

Table 10 30-year SAFEMAX rates

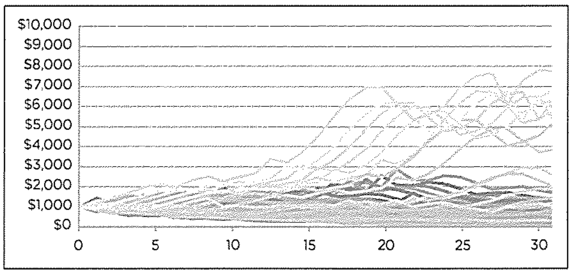
Asset allocation (rebalanced annually, 30 years)	Withdrawal rate as a percentage of initial portfolio value			
	SAFEMAX100	SAFEMAX95	SAFEMAX90	SAFEMAX50
100% stocks	2.93	3.14	3.40	5.25
75% stocks/20% bonds/5% bills	3.31	3.51	3.77	4.98
50% stocks/45% bonds/5% bills	**3.19**	**3.53**	**3.67**	**4.65**
25% stocks/70% bonds/5% bills	2.83	2.99	3.10	3.85
95% bonds/5% bills	2.04	2.12	2.16	3.35

Figure 14 SAFEMAX



SAFEMAX100 = 3.19%

Figure 15 4% Rule



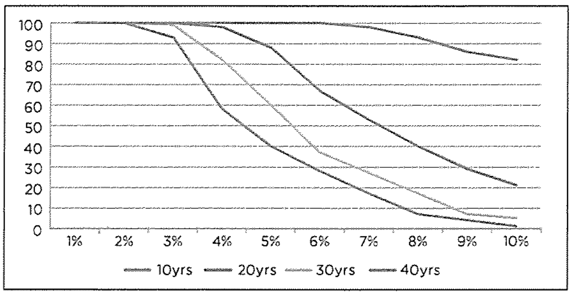
JAPAN

Over the last century, Japanese stocks (and bonds) have been a bottom quartile performer on a global comparison. Moreover, the correlation between Japanese stocks and bonds has average 0.38 over the same period. Japan provides the lowest SAFEMAX levels across the sample. In fact, less than 1 per cent (SAFEMAX equals 0.47 for the 100 per cent stock portfolio).

Table 11 Portfolio success rates

	Withdrawal rate as a percentage of initial portfolio value									
Payout	1%	2%	3%	**4%**	5%	6%	7%	8%	9%	10%
100% stocks										
10 yrs	94%	92%	91%	**91%**	90%	89%	86%	82%	75%	70%
20 yrs	86%	83%	78%	**74%**	70%	65%	60%	51%	45%	30%
30 yrs	84%	74%	66%	**61%**	59%	55%	40%	32%	22%	15%
40 yrs	81%	63%	50%	**49%**	44%	39%	32%	24%	19%	14%
75% stocks/20% bonds/5% bills										
10 yrs	94%	92%	92%	**91%**	91%	91%	88%	84%	83%	74%
20 yrs	86%	82%	80%	**78%**	72%	66%	62%	49%	38%	25%
30 yrs	80%	73%	67%	**62%**	59%	54%	41%	21%	13%	11%
40 yrs	72%	54%	49%	**49%**	44%	40%	28%	14%	13%	11%
50% stocks/45% bonds/5% bills										
10 yrs	94%	92%	92%	**91%**	91%	91%	89%	85%	84%	78%
20 yrs	84%	82%	80%	**80%**	75%	68%	55%	43%	28%	18%
30 yrs	76%	71%	68%	**62%**	57%	44%	26%	11%	10%	7%
40 yrs	67%	50%	49%	**47%**	42%	28%	14%	11%	8%	6%
25% stocks/70% bonds/5% bills										
10 yrs	93%	92%	92%	**90%**	90%	90%	88%	85%	84%	75%
20 yrs	83%	82%	79%	**79%**	75%	62%	47%	28%	18%	10%
30 yrs	73%	68%	66%	**60%**	45%	24%	13%	4%	1%	1%
40 yrs	54%	47%	46%	**43%**	22%	10%	4%	1%	0%	0%
95% bonds/5% bills										
10 yrs	93%	91%	91%	**90%**	89%	89%	86%	83%	68%	62%
20 yrs	80%	80%	78%	**78%**	55%	39%	34%	24%	15%	10%
30 yrs	70%	66%	65%	**39%**	20%	12%	6%	1%	1%	1%
40 yrs	49%	46%	40%	**13%**	6%	1%	0%	0%	0%	0%

Figure 16 Portfolio success rates comparison

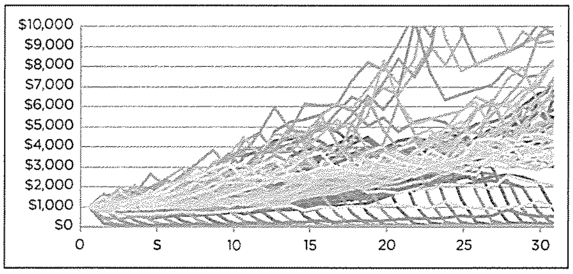


The Japanese experience in their stock, bond and bill markets provides some of the most interesting insights for safe withdrawal rates. Japan recorded the highest standard deviation of bonds over the last century (and third largest for stocks, see Appendix). This incredible dispersion of results has seen some sequences of returns (particularly those in the left tail of the distribution) lead to almost immediate portfolio ruin under any rule. Moreover, the incredible returns in the right tail have led to stellar gains for some paths (in fact, far better than the best paths experienced in Australia).

Table 12 30-year SAFEMAX rates

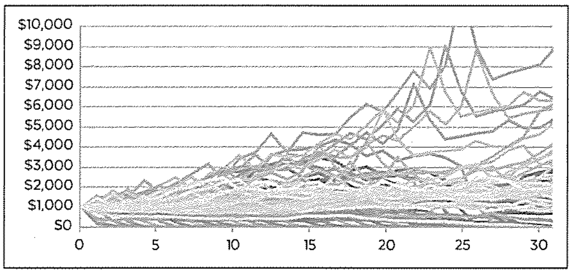
Asset allocation (rebalanced annually, 30 years)	Withdrawal rate as a percentage of initial portfolio value			
	SAFEMAX100	SAFEMAX95	SAFEMAX90	SAFEMAX50
100% stocks	0.47	0.49	0.54	6.52
75% stocks/20% bonds/5% bills	0.37	0.40	0.43	6.30
50% stocks/45% bonds/5% bills	**0.24**	**0.27**	**0.29**	**5.71**
25% stocks/70% bonds/5% bills	0.12	0.14	0.15	4.87
95% bonds/5% bills	0.04	0.05	0.06	3.71

Figure 17 SAFEMAX



SAFEMAX100 = 0.24%

Figure 18 4% Rule



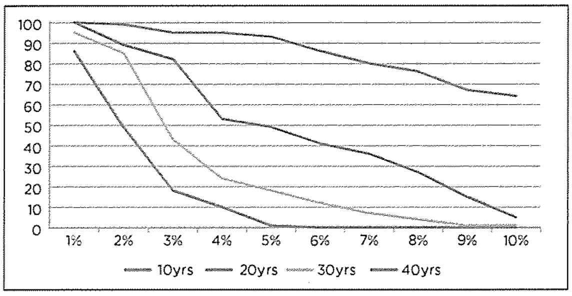
ITALY

Over many, many decades, stocks in Italy have barely kept pace with inflation (DMS, 2012). And while the Italian case study seems extreme, we are reminded of the wit and wisdom of Mark Twain when he said, 'Truth is stranger than fiction, but it is because Fiction is obliged to stick to possibilities; Truth isn't.' We find some SAFEMAX levels for the very shortest time periods and lowest payout levels; however, these results are troubling for the 4% Rule.

Table 13 Portfolio success rates

	Withdrawal rate as a percentage of initial portfolio value									
Payout	1%	2%	3%	**4%**	5%	6%	**7%**	**8%**	**9%**	**10%**
100% stocks										
10 yrs	100%	100%	99%	**97%**	90%	88%	82%	71%	62%	53%
20 yrs	100%	98%	82%	**64%**	54%	45%	32%	23%	21%	20%
30 yrs	100%	88%	61%	**37%**	27%	21%	13%	13%	9%	6%
40 yrs	100%	76%	42%	**24%**	17%	10%	4%	0%	0%	0%
75% stocks/20% bonds/5% bills										
10 yrs	100%	100%	97%	**95%**	94%	87%	81%	75%	65%	57%
20 yrs	100%	95%	85%	**58%**	53%	41%	34%	26%	20%	17%
30 yrs	100%	87%	50%	**28%**	23%	15%	12%	7%	4%	1%
40 yrs	99%	65%	31%	**17%**	10%	1%	0%	0%	0%	0%
50% stocks/45% bonds/5% bills										
10 yrs	100%	99%	95%	**95%**	93%	86%	80%	76%	67%	64%
20 yrs	100%	89%	82%	**53%**	49%	41%	36%	27%	15%	5%
30 yrs	95%	85%	43%	**24%**	18%	12%	7%	4%	1%	1%
40 yrs	86%	49%	18%	**10%**	1%	0%	0%	0%	0%	0%
25% stocks/70% bonds/5% bills										
10 yrs	100%	95%	94%	**92%**	88%	86%	82%	75%	69%	63%
20 yrs	89%	86%	74%	**53%**	45%	37%	30%	15%	9%	3%
30 yrs	84%	65%	29%	**20%**	11%	7%	2%	1%	1%	1%
40 yrs	64%	43%	11%	**0%**	0%	0%	0%	0%	0%	0%
95% bonds/5% bills										
10 yrs	96%	94%	92%	**52%**	88%	84%	79%	73%	68%	60%
20 yrs	86%	82%	70%	**9%**	41%	21%	17%	14%	10%	1%
30 yrs	74%	50%	23%	**0%**	5%	4%	2%	1%	1%	1%
40 yrs	47%	35%	0%	**13%**	0%	0%	0%	0%	0%	0%

Figure 19 Portfolio success rates comparison

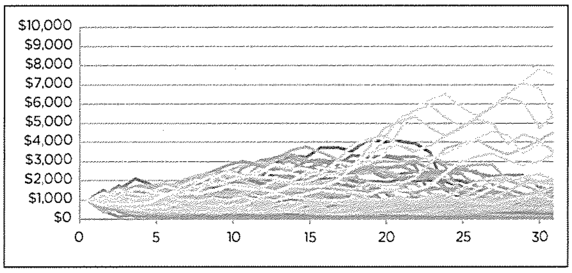


While Italian stocks recorded a similar level of standard deviation as Japan, bonds in Italy recorded a third less volatility when compared to Japanese bonds over the sample period. This has provided only marginally better overall safe withdrawal results than those recorded in Japan. Interestingly, investors were faced with around a one-in-four chance of the portfolio surviving a 4 per cent withdrawal level of 30 years. In addition to Japan, Italy provides a further interesting set of results when thinking about rule-based retirement income strategies.

Table 14 30-year SAFEMAX rates

Asset allocation (rebalanced annually, 30 years)	Withdrawal rate as a percentage of initial portfolio value			
	SAFEMAX100	SAFEMAX95	SAFEMAX90	SAFEMAX50
100% stocks	1.34	1.76	1.94	3.50
75% stocks/20% bonds/5% bills	1.31	1.50	1.84	3.00
50% stocks/45% bonds/5% bills	**0.89**	**1.01**	**1.23**	**2.66**
25% stocks/70% bonds/5% bills	0.45	0.50	0.55	2.49
95% bonds/5% bills	0.18	0.21	0.22	2.09

Figure 20 SAFEMAX



SAFEMAX100 = 0.89%

Figure 21 4% Rule

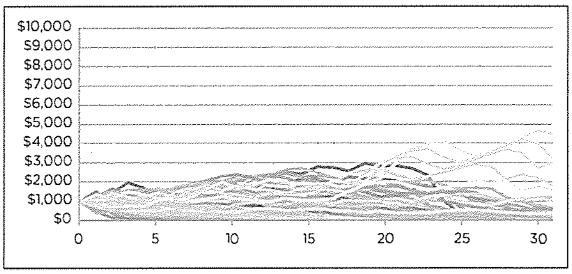
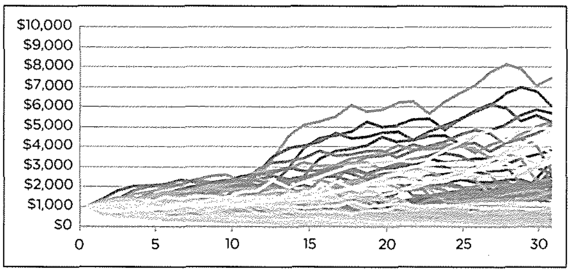
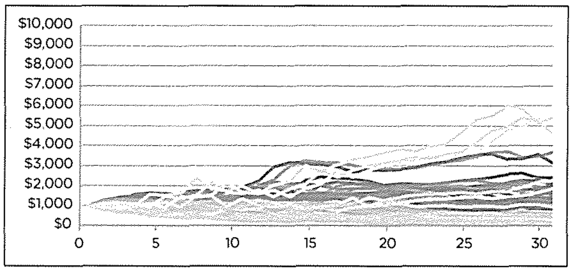


Figure 22 Heat maps of SAFEMAX results (50:50, 30 years)

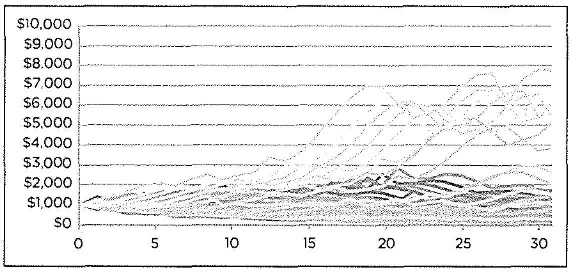
Australia 4% (SAFEMAX100 2.96)



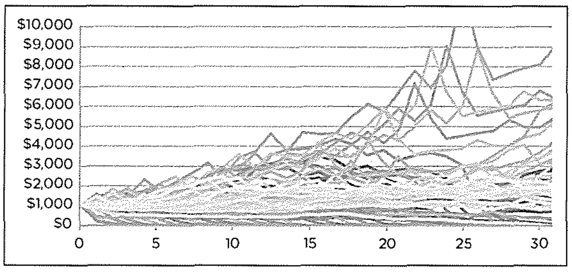
New Zealand 4% (SAFEMAX100 3.64)



Netherlands 4% (SAFEMAX100 3.19)



Japan 4% (SAFEMAX100 0.24)



Italy 4% (SAFEMAX100 0.89)

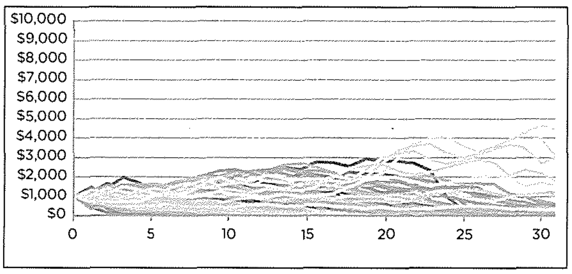


Figure 22 Heat maps of SAFEMAX results (50:50, 30 years) *continued*

Australia heat map

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	100%	100%	100%	100%	100%	100%	98%	93%	86%	82%
20 yrs	100%	100%	100%	98%	88%	67%	53%	40%	29%	21%
30 yrs	100%	100%	99%	82%	60%	37%	27%	17%	7%	5%
40 yrs	100%	100%	93%	58%	40%	28%	17%	7%	4%	1%

New Zealand heat map

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	100%	100%	100%	100%	100%	100%	100%	96%	94%	84%
20 yrs	100%	100%	100%	100%	92%	71%	46%	32%	26%	11%
30 yrs	100%	100%	100%	88%	52%	29%	16%	10%	6%	1%
40 yrs	100%	100%	100%	58%	32%	10%	3%	3%	0%	0%

Netherlands heat map

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	100%	100%	100%	100%	100%	100%	100%	99%	85%	70%
20 yrs	100%	100%	100%	100%	82%	55%	42%	33%	20%	12%
30 yrs	100%	100%	100%	70%	43%	22%	13%	9%	6%	4%
40 yrs	100%	100%	96%	42%	17%	3%	0%	0%	0%	0%

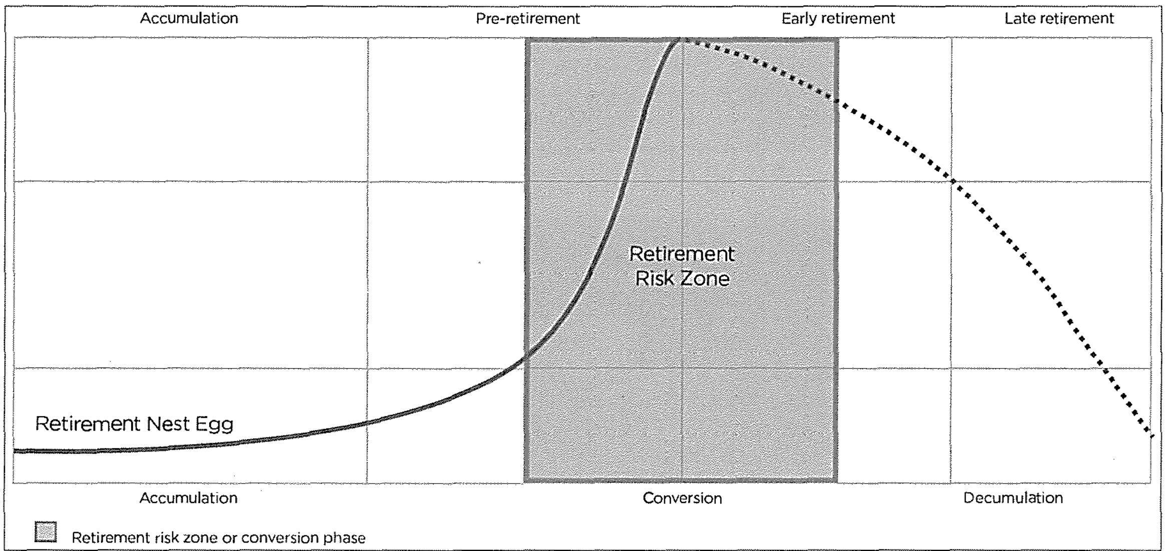
Japan heat map

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	94%	92%	92%	91%	91%	91%	89%	85%	84%	78%
20 yrs	84%	82%	80%	80%	75%	68%	55%	43%	28%	18%
30 yrs	76%	71%	68%	62%	57%	44%	26%	11%	10%	7%
40 yrs	67%	50%	49%	47%	42%	28%	14%	11%	8%	6%

Italy heat map

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	100%	99%	95%	95%	93%	86%	80%	76%	67%	64%
20 yrs	100%	89%	82%	53%	49%	41%	36%	27%	15%	5%
30 yrs	95%	85%	43%	24%	18%	12%	7%	4%	1%	1%
40 yrs	86%	49%	18%	10%	1%	0%	0%	0%	0%	0%

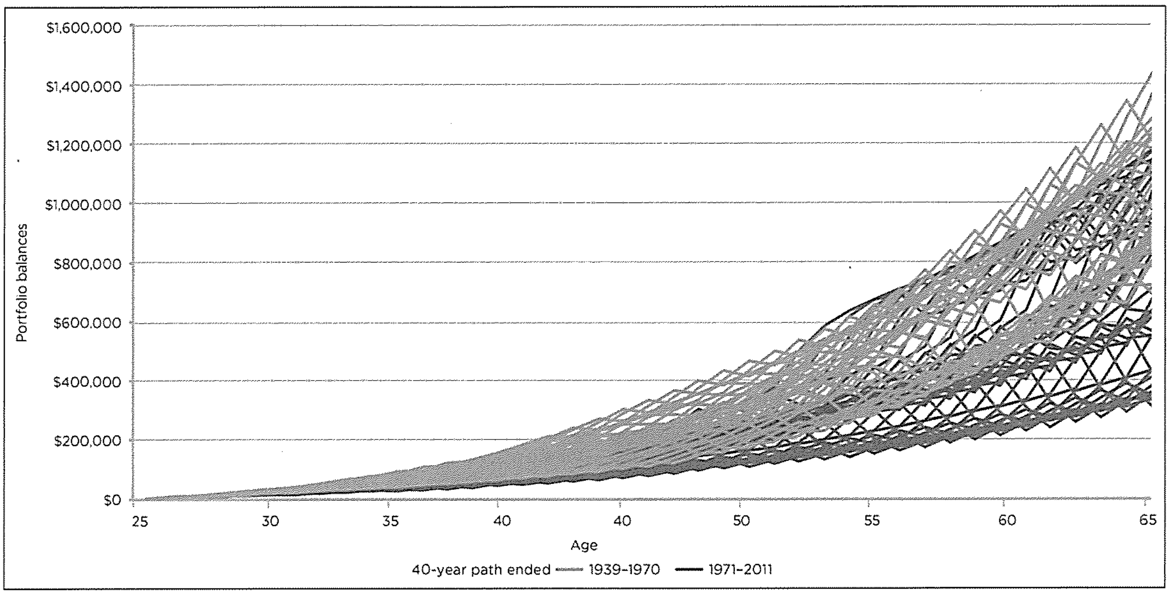
We opened the study with a discussion of the importance of the conversion phase, where retirees are in the final stages of their accumulation journey and are converting these savings into retirement income. The concept of the retirement risk zone explains complex investment principles for ordinary investors.



While acknowledging the illustrative power of the above figure, the findings of this paper (as well as those from the first paper in the Finsia RRZ research series on the topic of sequencing risk (Basu, Doran and Drew, 2012)) suggest that the myriad of risks facing investors are far, far greater than such stylised versions of the RRZ suggest. At the heart of this debate is the fact that success in retirement investing is heavily dependent on the cash flow profile of the investor — cash inflows during the accumulation phase and cash outflows during the income phase. The complexity of the task facing investors is exacerbated further by the multi-sequence, path-dependent nature of retirement outcomes.

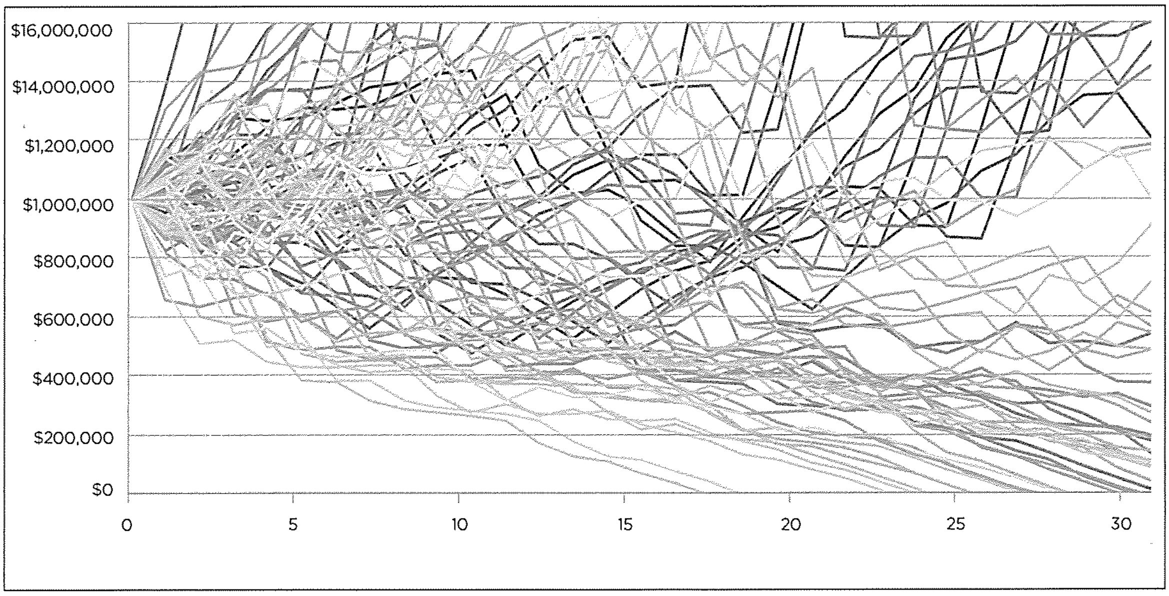
Going back to the first study in this series, Basu, Doran and Drew (2012, 2013) use the same data as employed in this study to illustrate the range of outcomes for a 25-year-old Australian contributing 9 per cent of salary over their lifetime. Using a 40-year investment horizon, with a 66:34 asset allocation of real returns, the research shows the fan of retirement outcome uncertainty during the accumulation phase.

Figure 23 Accumulation paths from 1900 to 2011



Source: Basu, Doran and Drew (2012)

Figure 24 Views from a multi-cash flow, multi-sequencing world



The results presented in Figure 23 highlight the range of results for our hypothetical investor, ranging from around $300,000 through to $1.5 million. Importantly, this analysis keeps the same cash contributions throughout, and the same asset allocation, and simply applies different 40-year paths of returns (from between 1900 and 2011) to determine the outcome. Moving from the accumulation phase through to the decumulation phase we must acknowledge just how heroic this and other safe withdrawal studies are by assuming the starting point for analysis — that is, the investor's final accumulation balance. Even with the uncertainties surrounding the final balance, our results demonstrate a similar fan of uncertainty facing retirees (Figure 24, Australia 4% Rule, starting balance of $1 million) as they enter the income phase.

We must do better in assisting retirees with formulating realistic expectations of the sustainability of their retirement savings.

In a world currently providing retirees (and investors more generally) with significant headwinds (low-risk investments offering low nominal returns and negative real returns for all but the very longest horizons; the constant tinkering of superannuation policy; and our seemingly ever increasing longevity), there is a very real temptation to look for a 'silver bullet' to solve the asset-liability mismatch facing retirees. As the dark shadow of complexity looms, surely there must be a 'fix-all' to the retirement income challenge? In many respects, the financial services industry (both in Australia and abroad), and governments have continued their search for the solution, retirement's holy grail.[19]

The framing of our approach to the income conversion phase is critical. It is important that we are cognisant of the holy grail dilemma; that we aren't spending too much time searching for a silver bullet to solve all ills. As we have seen in the analytical sections of this study, sequencing risk, record low interest rates, the dynamism of correlations between asset classes and constant shadow of inflation create an environment where, many times, the quest for a sustainable retirement income leads to decisions that simply exchange one risk for another.

Depressingly, fiscal death seems to be developing into a risk to rival that of physical death.

To start, we have to acknowledge the 'known unknown', that is, the path dependency of outcomes (resulting from the unknown sequence of returns). Our selection of five countries illustrates that, even with the best annualised performance of any stock market in the world over the past century, the 4% Rule could not be followed deterministically through time without some risk of portfolio ruin. Moreover, our friends in New Zealand and the Netherlands, third quartile and median performers in long-term real stock returns, respectively, sustained high safe withdrawal rates. In short, what happens when the largest amount of retirement savings is at risk, matters. While acknowledging that we have limited skills in forecasting whether or not the retiree gets the 'bad' draw out of the cosmic investing world, we can and we must do better in assisting retirees with formulating realistic expectations of the sustainability (or otherwise) of their retirement savings (assets) in meeting their income needs (liability).

We have entitled this section, 'The 4% Rule is dead, long live the 4% Rule'. We do this to underline the dangers of following this rule in a deterministic way. However, we can also see the merit in using the safe withdrawal rate approach to inform (and, perhaps lower) the income expectations of retirees. While we reject the 4% Rule as a retirement income strategy, we will argue that the underlying philosophy of the 4% Rule can be a very useful tool to frame the liability aspect of retirement planning, and assist retirees with forming expectations.

Our results confirm that whatever you think you need as a superannuation nest egg, it is almost certainly going to be less than you actually need.[20] The conversation is a difficult one in that, for many investors, their focus is on the asset side (particularly, the return portion) of the equation, not the liability. We posit that the first challenge in tipping the scales in the retiree's favour is to get the framing right, moving from a 'pot of gold' (asset) mindset to an 'income replacement' focus (liability).

19 As students, the authors (particularly the first named author) followed a little Australian pub band, known as the Hunters and Collectors. Perhaps Hunters and Collectors lead singer, Mark Seymour, frames it best when he penned: 'Woke up this morning from the strangest dream. I was in the biggest army the world has ever seen. We were marching as one. On the road to the holy grail.' We take this opportunity to pay homage to the first named author's favourite band, H&C, the anthems of our generation and their insights into the retirement product debate, see: <http://www.markseymour.com.au/>.

20 For an excellent discussion, and accompanying analytics, regarding this issue see Deloitte (2013) report on the 'Dynamics of the Australian Superannuation System: The next 20 years', <http://www.deloitte.com/view/en_AU/au/industries/financialservices/dynamics-superannuation/index.htm>.

It's time for a difficult conversation. Let's assume (somewhat heroically) that a couple has a retirement nest egg of $1 million today.[21] How can we begin to assist retirees with framing reasonable expectations given different starting balances?

The first challenge in tipping the scales in the retiree's favour is to get the framing right, moving from a 'pot of gold' mindset to an 'income replacement' focus.

The Association of Superannuation Funds of Australia (ASFA) has developed the ASFA Retirement Standard benchmarks that estimate the annual budget needed by Australians to fund either a comfortable or modest standard of living in retirement. It is updated quarterly to reflect inflation, and provides detailed budgets of what singles and couples would need to spend to support their chosen lifestyle. We argue that these benchmarks are a critical component to improving the framing of retirement income decisions. The ASFA Retirement Standard (June quarter 2013) shows that, in general, a couple looking to achieve a 'comfortable' retirement needs to spend $56,406 a year, while those seeking a 'modest' retirement lifestyle need to spend $32,656 a year (ASFA, 2013).[22]

For the purposes of providing a practical perspective to the safe withdrawal debate, we can consider (on a $1 million starting balance), a real income requirement of 3.27 per cent (that is, 3.27 per cent of $1 million = $32,700 per annum for 30 years) for a modest income level; and a 5.64 per cent for a comfortable income (5.64 per cent of $1m = $56,400 p.a. for 30 years). To provide a further yardstick for comparison, the age pension rate for a combined couple (using the maximum basic rate, and excluding the maximum pension supplement and the clean energy supplement) stands at around $29,463 (2.94 per cent).[23] These three income levels provide an indicative income liability for a couple in retirement of between $30,000 and $60,000 per annum (we acknowledge that, for many Australian couples, even the upper end of this range would not represent a life of 'endless summers, candlelit dinners and long walks along the beach'). We plot these ranges against our safe withdrawal rate findings (note that the dotted lines represent the ASFA modest and comfortable income levels on a starting balance of $1 million).

21 We note that the majority of studies use this accumulated level as the starting point for testing safe withdrawal rates, by way of example, see Bengen (1994); through to more recent studies by Athavale and Goebel (2011) and Finke, Pfau, and Williams (2012).

22 For a more detailed view of the expenditure components in the ASFA Retirement Standard (and the methodological approach, see: <http://www.superannuation.asn.au/resources/retirement-standard>.

23 Perhaps the age pension could be considered a form of back-stop annuity. We find the approximately 3 per cent withdrawal level (2.94 per cent) on a starting balance of $1 million particularly useful as a lower bound. It also highlights just how modest the ASFA modest standard is. Using back-of-the-envelope numbers, ASFA's 'modest' standard equates to an extra $115 per fortnight over and above the maximum basic rate for a couple.

Figure 25 ASFA retirement income standards as withdrawal rates*

Australia

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	100%	100%	100%	100%	100%	100%	98%	93%	86%	82%
20 yrs	100%	100%	100%	98%	88%	67%	53%	40%	29%	21%
30 yrs	100%	100%	99%	82%	60%	37%	27%	17%	7%	5%
40 yrs	100%	100%	93%	58%	40%	28%	17%	7%	4%	1%

New Zealand

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	100%	100%	100%	100%	100%	100%	100%	96%	94%	84%
20 yrs	100%	100%	100%	100%	92%	71%	46%	32%	26%	11%
30 yrs	100%	100%	100%	88%	52%	29%	16%	10%	6%	1%
40 yrs	100%	100%	100%	58%	32%	10%	3%	3%	0%	0%

Netherlands

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	100%	100%	100%	100%	100%	100%	100%	99%	85%	70%
20 yrs	100%	100%	100%	100%	82%	55%	42%	33%	20%	12%
30 yrs	100%	100%	100%	70%	43%	22%	13%	9%	6%	4%
40 yrs	100%	100%	96%	42%	17%	3%	0%	0%	0%	0%

Japan

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	94%	92%	92%	91%	91%	91%	89%	85%	84%	78%
20 yrs	84%	82%	80%	80%	75%	68%	55%	43%	28%	18%
30 yrs	76%	71%	68%	62%	57%	44%	26%	11%	10%	7%
40 yrs	67%	50%	49%	47%	42%	28%	14%	11%	8%	6%

Italy

Payout	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
10 yrs	100%	99%	95%	95%	93%	86%	80%	76%	67%	64%
20 yrs	100%	89%	82%	53%	49%	41%	36%	27%	15%	5%
30 yrs	95%	85%	43%	24%	18%	12%	7%	4%	1%	1%
40 yrs	86%	49%	18%	10%	1%	0%	0%	0%	0%	0%

*The white dotted lines in the country charts above represent ASFA modest income standard (left) and ASFA comfortable income standard (right).

We can consider the ASFA benchmarks as forming a retirement income channel through which retirees are attempting safe passage (in this case, safe passage is avoiding portfolio ruin). Even if we exclude the countries with the lowest safe withdrawal rate results (Japan and Italy), the results on a starting balance of $1m for a couple suggest that the ASFA modest range is vastly more sustainable than the comfortable equivalent. Even at this withdrawal rate, history suggests that a couple would still face somewhere between a 10 to 30 per cent chance of portfolio ruin for a 30-year horizon.

As a form of 'ready reckoner', we include in the table below different starting points, and their safe withdrawal equivalent percentage.

Table 15 Withdrawal rates equivalents for varying starting values

Starting balance	ASFA modest $32,656	ASFA comfortable $56,406
$250,000	13.06%	22.56%
$500,000	6.53%	11.28%
$750,000	4.35%	7.52%
$1,000,000	**3.27%**	**5.64%**
$1,250,000	2.61%	4.51%
$1,500,000	2.18%	3.76%

In short, holding a 50:50 portfolio over 30 years, the highest SAFEMAX100 rate we report in this study is from New Zealand at 3.64 per cent. This suggests that even using the best result from our sample, a couple with a starting balance of $1.5m would, using history as a guide, still face some probability of portfolio run. We again acknowledge the limitations of the 4% Rule, particularly the deterministic nature of the rule. In the real world, retirees face an array of expenses, the frequency of which range from well-known (such as utility bills, insurance costs, general living expenses) to some which are stochastic or random in nature (for instance, major unanticipated health events). However, as previously mentioned, the 4% Rule used as a 'line in the sand' can be very helpful as a heuristic for retirees (a quick shortcut to assist in our understanding the challenge of income planning). Like many shortcuts, it provides an imperfect answer to help us better understand the problem (and formulate more robust responses). As neatly summarised by Scott, Sharp, and Watson (2009), the 4% Rule imposes an opportunity cost on retirees and is therefore inefficient. We would certainly echo their view. The 4% Rule helps us initially engage cognitively in the retirement income problem which, as we have seen from this study, is simultaneously complex and dynamic in nature.

The 4% Rule is dead, long live the 4% Rule.

RETIREMENT INCOME PLANNING: THE NEXT STEPS

> *'There are known knowns; there are things we know that we know. There are known unknowns; that is to say, there are things that we now know we don't know. But there are also unknown unknowns — there are things we do not know we don't know.'*
>
> *Former United States Secretary of Defense, Donald Rumsfeld*

As mentioned in the previous section, we have limited skills in forecasting whether or not the retiree gets the 'bad' draw out of the cosmic investing world. In the words of Mr Rumsfeld, we consider this a 'known unknown'. We know that if the sequence of returns is against us (particularly when the largest amount of our nest egg is at risk) and the timing is wrong, the reality is that some investor is going to get the 5 per cent worst outcome.

However, there are many levers that can be coordinated to tip the scale in the favour of the retiree, including more dynamic approaches to the:

> Withdrawal rate

Through mortality updating, regular mid-point reviews and updating of the cash flow profile of retirees.

> Asset allocation

Our results suggest that going defensive doesn't necessarily work and can potentially lock in a bad outcome; being judicious about selling expensive assets through time and not being a forced seller due to liquidity needs; liability-driven investment.

> Planning horizon

Working longer and phased retirement results in saving more and shortening the income period Consider also: aged care costs; medical expenses; bequest motive.

> Fees and after-tax management

We need to start to think of the fee debate as something more than an expense, but rather a budget to assist retirees in managing their asset-liability mismatch. After all, retirees live on after fee, after-tax outcomes.

> Scenario testing

We need to regularly update our retirement expectations; that is, the liability we need to meet and the asset base with which we must achieve this. Identifying this can be informed by a range of simulation techniques.

> Risk management

Our findings highlight that a tail event in the early stages of the income phase almost ensures portfolio ruin. We insure for a range of events in our life — home and contents, life and disability — why would we not insure against tail events late in our accumulation phase and early in the income phase?

> Investment governance

We need to ensure that we have trustees that can understand the asset-liability mismatch faced by retirees. As we have seen, the mismatch is a multi-dimensional problem: a complex interplay between market risk, longevity risk, and inflation risk. This requires more than, 'did we beat peers' or 'can we pick stocks?' We need to break our current obsession with the return characteristics of the asset side of the equation and move the fiduciary focus to liability management.

We acknowledge that this is not an exhaustive list. However, these are some of the key levers that our research findings suggest can fall within the gambit of 'known knowns'.

A recurrent theme throughout this study has been the role of cash flows. The biggest difference between the accumulation phase and the retirement income phase is that the cash flow profile moves from inflows (hence increasing liquidity) to outflows (hence decreasing liquidity). Importantly, as we move into retirement, time frames also shrink. Moreover, the amount of money available for long-term investments (and therefore strategies that might take a decade or more to work) also shrinks. The practical takeaways from this research are the dynamic nature of the problem, and strategies that are built on a philosophy of dynamism are key to putting the balance of probabilities in the retiree's favour.

The combination of cash outflows and shorter time horizons changes our perspective on the risk of investing in stocks. Equity risk becomes even more risky, with retirees exposed to the very real chance of a permanent loss of capital (particularly detrimental if this occurs within, say, the first seven years of the income phase). However, as our results have shown, retirees would require astronomical retirement nest eggs to immunise their retirement income liability. Our results suggest that nothing is risk-free in retirement investing, even government bonds and bills.

The days of searching for the retirement income silver bullet are over. In this study, the 4% Rule works for favourable sequences of returns (let's be honest, everything works in such markets), ignores asset values of the day and is decoupled from the dynamic nature of the asset-liability mismatch faced by many Australians. However, the 4% Rule does present us with an opportunity to form a baseline which can dramatically improve our expectations of what's possible in retirement.

For the future, we need to move from a silver bullet approach (such as the 4% Rule) to a veritable arsenal of weapons (based on dynamism: withdrawal rates; asset allocation; planning horizon; fees and after-tax management; scenario testing; risk management; investment governance) to assist retires in managing and mitigating the asset-liability mismatch in retirement.

Strategies that are built on a philosophy of dynamism are key to putting the balance of probabilities in the retiree's favour.

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APPENDIX SUMMARY STATISTICS

Country	Annualised performance (inflation)	Arithmetic mean (inflation)	Standard deviation (inflation)	Annualised performance (real bills)	Arithmetic mean (real bills)	Standard deviation (real bills)	Correlation (bills, bonds)	Correlation (bills, equities)	Annualised performance (real bonds)	Average performance (real bonds)	Standard deviation (real bonds)	Correlation (bonds, equities)	Annualised performance (real equity)	Average performance (real equity)	Standard deviation (real equity)
Australia	**3.9**	**4.0**	**5.2**	**0.7**	**0.8**	**5.4**	**0.6**	**0.2**	**1.6**	**2.4**	**13.2**	**0.25**	**7.2**	**8.9**	**18.2**
Belgium	5.3	5.7	8.9	-0.4	0.0	8.0	0.7	0.2	-0.1	0.6	11.9	0.40	2.4	5.0	23.6
Canada	3.0	3.1	4.6	1.6	1.7	4.9	0.6	0.1	2.2	2.7	10.4	0.16	5.7	7.1	17.2
Denmark	3.9	4.1	6.1	2.2	2.4	6.0	0.6	0.1	3.2	3.8	11.7	0.45	4.9	6.7	20.9
Finland	7.3	9.0	26.7	-0.5	0.5	11.8	0.9	0.3	-0.2	1.1	13.6	0.30	5.0	9.0	30.4
France	7.2	7.8	12.3	-2.8	-2.3	9.5	0.8	0.2	-0.1	0.8	13.0	0.37	2.9	5.5	23.5
Germany	4.7	5.6	15.0	-2.4	-0.4	13.2	0.8	0.3	-1.8	0.9	15.5	0.43	2.9	7.9	32.2
Ireland	4.2	4.5	6.9	0.7	0.9	6.6	0.7	0.4	0.9	2.0	14.8	0.50	3.7	6.3	23.1
Italy	**8.4**	**10.8**	**34.8**	**-3.6**	**-2.6**	**11.5**	**0.9**	**0.3**	**-1.7**	**-0.5**	**14.0**	**0.40**	**1.7**	**5.7**	**29.0**
Japan	**6.9**	**10.3**	**41.6**	**-1.9**	**-0.3**	**13.9**	**0.7**	**0.4**	**-1.1**	**1.6**	**20.0**	**0.38**	**3.6**	**8.3**	**29.8**
Netherlands	**2.9**	**3.0**	**4.7**	**0.7**	**0.8**	**4.9**	**0.6**	**0.0**	**1.5**	**1.9**	**9.4**	**0.07**	**4.8**	**6.9**	**21.8**
NZ	**3.7**	**3.8**	**4.6**	**1.7**	**1.8**	**4.7**	**0.7**	**0.2**	**2.1**	**2.5**	**9.1**	**0.30**	**5.8**	**7.5**	**19.7**
Norway	3.7	4.0	7.3	1.2	1.4	7.1	0.8	0.2	1.8	2.5	12.2	0.17	4.1	7.1	27.3
Sth Africa	4.9	5.2	7.5	1.0	1.2	6.2	0.7	0.2	1.8	2.3	10.3	0.43	7.2	9.4	22.5
Spain	5.8	6.0	6.9	0.3	0.5	5.8	0.6	0.2	1.3	2.0	11.7	0.35	3.4	5.7	22.2
Sweden	3.6	3.8	7.2	1.8	2.1	6.8	0.7	0.2	2.6	3.3	12.4	0.20	6.1	8.5	22.9
Switzerland	2.3	2.4	5.2	0.8	0.9	5.0	0.8	0.3	2.2	2.6	9.3	0.38	4.1	6.0	19.7
UK	4.0	4.2	6.6	1.0	1.2	6.4	0.6	0.3	1.5	2.4	13.8	0.51	5.2	7.1	19.9
US	3.0	3.1	4.8	0.9	1.0	4.7	0.5	0.2	2.0	2.5	10.3	0.18	6.2	8.2	20.2
World	3.0	3.1	4.8	0.9	1.0	4.7	0.6	0.2	1.7	2.3	10.4	0.42	5.4	6.9	17.7
World Ex-US	3.0	3.1	4.8	0.9	1.0	4.7	0.5	0.2	1.3	2.3	14.2	0.62	4.8	6.8	20.4
Europe	3.0	3.1	4.8	0.9	1.0	4.7	0.4	0.2	0.9	2.0	15.3	0.62	4.6	6.7	21.5

Source: DMS (2012). (For Germany, summary statistics for inflation are calculated excluding the period of hyperinflation of 1921 and 1922.)

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ABN 96 066 027 389 ACN 066 027 389
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The Role of Asset Allocation in Navigating the Retirement Risk Zone

First published April 2015
Published by: Finsia — Financial Services Institute of Australasia, Level 18, 1 Bligh, Sydney NSW 2000 Australia

ACN 066 027 389 ABN 96 066 027 389

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About the authors
Michael E Drew, PhD SF Fin, Professor of Finance at Griffith University and Director at Drew, Walk & Co.

Adam N Walk, PhD SF Fin, Research Fellow at Griffith University and Director at Drew, Walk & Co.

Jason M West, PhD SF Fin, Associate Professor of Informatics at Bond University.

The authors thank Robert J Bianchi, PhD SF Fin, Associate Professor of Finance, Griffith University, for his helpful comments. All errors are the sole responsibility of the authors.

Suggested citation
Drew, ME, AN Walk and JM West, 2015, *The Role of Asset Allocation in Navigating the Retirement Risk Zone*, Finsia (Financial Services Institute of Australasia), Sydney.

Further information and comments
Caroline Falshaw A Fin — Head of Corporate Affairs and Policy

W > finsia.com/retirementriskzone

E > c.falshaw@finsia.com

FOREWORD

Finsia's research series about retirement adequacy addresses the challenges facing Australia's superannuation system to improve the sustainability of retirement savings for all Australians.

How superannuants fare in retirement, and issues raised by increasing population longevity, have taken centre stage, particularly through the recommendations of the Financial System Inquiry and the Intergenerational Report. It is clear that policy initiatives must place a greater focus on the sustainability of retirement income through the many stages of retirement.

The first report in the Finsia series — *Sequencing Risk: A Key Challenge to Creating Sustainable Retirement income* — examined the effect of the ordering or sequencing of investment returns on the sustainability of retirement income.

The findings by Professor Michael Drew SF Fin, Dr Anup Basu F Fin and Brett Doran were based on simulations from a century of historical investment returns and challenged the belief that average return of investment determines the quality of retirement outcomes.

Through this research the authors identified the 'Retirement Risk Zone' — the period encompassing the final 20 years of the retirement saving journey and the initial 15 years of retirement. In this period, retirement savings are at their peak, and most exposed to risk. Importantly, it is in this period that superannuants shift from accumulating to decumulating their retirement savings.

The second report in the research series by Professor Michael Drew SF Fin and Dr Adam Walk SF Fin — *How Safe Are Safe Withdrawal Rates in Retirement? An Australian Perspective* — challenged the orthodoxy that withdrawing retirement savings at the rate of 4 per cent per annum ('the 4% Rule') is safe. They did so by analysing the annualised performance of different investments in a number of countries over a period of 112 years.

Even with the exceptional performance of the Australian stock market over the past century, a 4 per cent withdrawal rate over 30 years on a 50:50 growth/defensive asset allocation was found to come with 20 per cent chance of financial ruin. This finding raises the question of how investors and the industry can respond to ensure that superannuation savings form the basis of sustainable income for retirement.

In this third stage, the series authors, aided by Jason West, have developed an innovative and practical asset allocation strategy in order to maximise retirement outcomes. They advocate a dynamic layered asset allocation as one approach to maximise retirement income.

Significantly, the authors preferred strategy breaks the asset allocation of an investment portfolio across five stages recognising the changing needs of investors across the lifecycle. Recognising and accounting for these changing needs is critical to ensuring adequate standards of living in retirement.

Russell Thomas F Fin
CEO and Managing Director
Finsia

CONTENTS

1. INTRODUCTION

1.1 To and through the retirement risk zone

> *"I am more concerned about the return of my money, than the return on my money."*
>
> *Mark Twain*

It is common for many approaching retirement, and for the recently retired, to experience high levels of anxiety. One recent (informal) survey suggested that respondents' reactions to word 'retirement' were fairly evenly split between positive and negative sentiments (Carole, 2014). Negative sentiments included words such as: scared, nervous, anxious, worried, and sad. One particular factor that contributes to these negative sentiments is concern over financial security in retirement. Sleepless nights, hasty investment decision making, erratic spending patterns in response to market volatility, and nervousness about outliving financial wealth are some of the symptoms. The anxiety exists for good reason. The problem of ensuring a sustainable retirement income is a difficult and complex one for many folks, filled with uncertainties. The retiree has to balance regular spending needs against a range of 'known unknowns': investment returns, potentially significant medical and aged care costs, and the retiree's planning horizon.

FIGURE 1: Word cloud analysis of financial advice and retirement websites and client comments in Australia, 2012–14

We know that the anxiety may actually start earlier, in the so-called 'transition (or conversion) phase' to retirement. In addition to concerns about financial security, individuals also may face uncertainty about such things as involuntary or unexpected job loss and potential deterioration in mental or physical health. A number of scholars have studied the anxiety levels of people transitioning to retirement (Mein et. al. 2003; Gill et al. 2006; Villamil, 2006; Olesen, 2012). The majority of these studies have shown that anxiety levels are highest for those facing the greatest exposure to financial insecurity. But high anxiety can also extend to those who believe they have insufficient funds to sustain retirement, regardless of whether this belief is reasonable. Such beliefs are particularly dangerous when they go on to adversely affect the individual's investment decisions.

Instinctively, many folks are aware of the financial realities they face during the transition to retirement (e.g. the loss of regular non-investment income, heightened spending patterns in early retirement, and the legacy of existing debts). Above all, perhaps the greatest risk to their financial security is the potential for cumulative losses in their retirement portfolio during the so-called 'Retirement Risk Zone' — i.e. in the years immediately before and after their retirement date.[1] A sequence of poor returns in a highly exposed retirement portfolio can deplete wealth to such a degree that postponing retirement for another 5 to 7 years may still be insufficient to allow a full recovery. The impact of these losses — known as 'sequencing risk' — was the focus of the first instalment in Finsia's research program on the Retirement Risk Zone (Basu, Doran and Drew, 2012).

Investors concerned about the potential for large losses during this critical life stage may understandably be tempted to adopt a conservative investment approach. Eliminating as much risk as possible through the allocation of portfolio wealth to low risk assets might appear to be the appropriate response for many people entering the twilight of working life. According to this narrative, the preservation of capital is the overriding objective.

But this approach assumes that investors are best served by short-term protection over longer-term growth. The second report in Finsia's Retirement Risk Zone research program estimated safe withdrawal rates for a number of investment strategies in a number of countries using historical simulation (Drew and Walk, 2014). It found that adopting an overly conservative investment strategy resulted in low safe withdrawal rates, and that risky assets have their place in retirement portfolios.

Someone entering the retirement risk zone (at, say, age 55) will, on average, continue to live, love, travel, eat and drink (!) for another 30 years. This investment horizon represents around two-thirds of the working life of most full-time employees and almost one-third of one's entire life (based on current life expectancy). Regardless of context, 30 years represents a long investment horizon. Advising this person to invest their current retirement portfolio conservatively means that their current wealth, plus any future conservatively-invested contributions, is arguably as much as they will ever have to finance their retirement income needs. For most, adopting this approach will yield a lump sum at retirement that is completely inadequate. Such an outcome can motivate individuals to exhaust their portfolio on retiring their mortgage, spending on home renovations and holidays, and gifting wealth to their children while looking to the age pension to at least partially supplement their spending needs.

This third instalment in Finsia's Retirement Risk Zone series builds on the previous two studies in the series:

> *Sequencing Risk: A Key Challenge to Sustainable Retirement Incomes* highlighted the role of path dependency in retirement outcomes (Basu, Doran and Drew, 2012)

> *How Safe are Safe Withdrawal Rates in Retirement? An Australian Perspective* explored the limitations of the 'golden' or four per cent rule as a retirement income strategy in account based pensions (Drew and Walk, 2014).

The first report on sequencing risk was largely concerned with a timeframe 'to-retirement'; with the second report on withdrawal rates concerned with 'post-retirement' (or through-retirement). Unlike these studies, this analysis looks at the journey both to and through the retirement date, starting with early working life (25 years of age) through to late retirement (90 years of age) — a span of some 65 years.

At its heart, the report views the sustainability (or otherwise) of retirement income as primarily a function of asset allocation.

It is timely at this juncture to be clear on what this study is and *what it is not*. At its heart, the report views the sustainability (or otherwise) of retirement income *as primarily a function of asset allocation*. Therefore, we are concerned with testing various approaches to asset allocation through the life course (early accumulation; late accumulation; pre-retirement transition; post-retirement transition; stable retirement; and life expectancy). Given the enormity of the asset allocation task, we leave other key issues in the retirement income debate (defined ambition funds; guaranteed minimum withdrawal benefit (GMWB) (and variants) annuity contracts; immediate and deferred annuities; longevity insurance; pooling; phased retirement) to others.[2] As we have learnt from scholars such as Brinson, Hood and Beebower (1986) almost 30 years ago, asset allocation is a primary driver of retirement outcomes. This report seeks to provide positive insights into the debate regarding competing asset allocation approaches over the life course, where retirement income is used as the objective function.

1 This report is one of a series about the Retirement Risk Zone. Please refer to Finsia's website for further information: www.finsia.com/retirementriskzone.

2 We acknowledge that these competing approaches to the challenge of creating sustainable retirement incomes for investors are important to the debate. The approach developed in this report is sufficiently flexible that adding these design features can be entertained at a later time.

In the next section we consider the rise of different approaches to the difficult problem of asset allocation (or portfolio selection) through various life stages. It has been said that "what's safe and what's risky changes over your life" (Drew and Walk, 2014). In essence, this report considers the role of asset allocation in navigating both to, and through, the Retirement Risk Zone.

1.2 The evolution of investing across the life course

What is the best way to undertake asset allocation decisions over a lifetime? This question has been considered by leading economists, practitioners and mum-and-dad investors alike.

What is the best way to undertake asset allocation decisions over a lifetime?

Uncertainty in retirement planning is the result of unknown future labour income and the variable return on the assets in which retirement savings are invested. We need to systematically form a view about both the trade-off between consumption in different states in the same time period and the trade-off between consumption and consumption variability in different time periods over a largely unknown planning horizon. Attitudes and expectations related to these trade-offs will influence the optimal funding and investment strategies for a given individual's pension plan. In short, what is the best asset allocation approach to ensure the sustainability of retirement income (and minimisation of portfolio ruin)?[3]

To protect wealth from volatile asset returns during the Retirement Risk Zone period many investors use of 'off-the-shelf' solutions, such as target date funds (TDFs, also known as lifecycle funds). These funds initially have high allocations to stocks and then shift allocations towards less volatile assets like bonds and cash as the target retirement date approaches. Empirical research has generally found that switching to low-risk assets prior to retirement can reduce the risk of confronting the most extreme negative outcomes. It is further claimed that such lifecycle investment strategies reduce the volatility of wealth outcomes making them desirable to investors who seek a reliable estimate of their final pension in the years prior to retirement (Blake et al., 2001).

However other scholars show that these benefits come at a substantial cost to the investor. This cost is the sacrifice of significant upside potential wealth accumulation offered by more aggressive strategies (Booth and Yakoubov, 2004; Byrne et al., 2007; Basu and Drew, 2009). Bodie and Treussard (2007) argue that deterministic target date funds are optimal for some investors, but not for others, with suitability depending on the investor's risk aversion and human capital risk.

A variety of studies attempt to optimise retirement portfolios through the use of the following methods:

> a declining equity glide path (e.g. where equity exposure is lowered as people get older)

> a static fixed allocation (Bengen, 1996; Blanchett, 2007)

> a rising equity glide path (e.g. the portfolio is initially conservative and becomes more aggressive through the retirement period (see the work of Pfau and Kitces, 2014 based on the based on the portfolio size effect work of Basu and Drew, 2009) to minimise the probability of ruin during retirement).

Each approach claims to reduce the probability of ruin, and bring about improvements in the risk characteristics of portfolios. These claims depend heavily on the portfolio return experienced by investors as well as the timing of such returns. As shown in Byrne, et al. (2011), a poor sequence of returns may be detrimental to a cohort approaching retirement while it may have little effect on other cohorts of investors, such as those deep into the retirement phase. In most analyses of this phenomenon, and in how investment managers like to frame the response, a heavy dependency is placed on the impact to the investor's 'glide path'.

TDFs gradually reduce their exposure to stocks as investors approach the target date of retirement. Notwithstanding this design feature, pre-programmed lifecycle strategies remain potentially vulnerable to sequencing risk. This can translate into an investment profile that accumulates too little wealth during the initial years of the strategy and fails to justify switching to more conservative assets in the later stages of the investor's planned retirement (Basu, et al., 2011).

3 Although not a cheery concept, portfolio ruin in this context is the risk of retirement capital being exhausted. Typically, this risk is considered in terms of the probability of the event (ruin) occurring.

Recent research has suggested that the optimal allocation to risky assets resembles a 'V' (or in some cases a displaced V — Kingston and Fisher, 2013). The share of growth assets declines in the order of 20 to 50 percentage points over an individual's working life up to the day of retirement and then rises again during the drawdown phase, again by the order of 20 to 50 percentage points. The V (or displaced V in cases where a discrete shift away from growth assets occurs) is dynamically derived (rather than pre-determined) in order to respond to the goal-oriented outcomes desired by investors. For example, Pfau and Kitces (2014) find that for investors who wish to protect against the most adverse outcomes, owning a more conservative portfolio at the start of retirement and allowing equities to drift higher in retirement is an effective strategy for maximising wealth when they die. Rising equity glide paths therefore show a modest but persistent benefit by aiding the portfolio's sustainability in the worst sequences.

Basu et al. (2011) demonstrate that deterministic switching rules may produce inferior wealth outcomes for investors compared to dynamic strategies that alter the allocation between growth and conservative assets based on cumulative portfolio performance relative to a set target. Dynamic allocation strategies exhibit almost stochastic dominance (ASD) over strategies that deterministically switch the asset allocation without regard for underlying portfolio performance (see Basu et al., 2011 for further discussion).

The findings of this research motivate the examination of whether dynamism of asset allocation (informed by a pre-determined outcome or goal) is an investment philosophy that results in superior retirement outcomes. Dynamism is a key factor underlying the recent notion of 'goal-oriented investing'; that is, in order to achieve retirement goals it is necessary to actively adjust portfolio settings in the face of volatile financial markets.

Prescriptive glide paths offer little flexibility to adjust asset allocations if market conditions change. For instance, the automatic scaling back of allocations to growth assets in the transition-to-retirement phase — to protect against sequencing risk — may mean that investors forego significant wealth generation potential if stock prices are already depressed by historical standards, and the market stands on the cusp of a boom. Similarly, if stocks are overvalued relative to history, then automatically switching to stocks through the retirement phase may result in sub-optimal outcomes. Thus, merely taking a long-term view on growth assets may not be sufficient to enable portfolio recovery given the short time horizon faced by many retirees.

Mean reversion in asset returns is a contentious issue which leads to heated debates about market timing and active management. The extent of the debate is summarised in Campbell and Shiller (2001) and Benson, Bortner and Kong (2011). However a simple relative value measure, especially for stocks, can potentially be used to derive a medium-term forecast of asset class returns (Campbell and Shiller, 1988). This forecast can then be used as the basis for a dynamic portfolio strategy aimed at managing sequencing risk and improving dollar-weighted returns. Therefore, in light of the work by Campbell and Shiller (1998) and others, it is also timely to examine whether there is a repeatable and effective way to adjust the investment portfolios based on valuations that yields better retirement outcomes.

In this analysis, we consider various extant designs that are used in the market today (such as the prescriptive glide paths used by off-the-shelf TDF providers) through to current innovations in the lifetime asset allocation debate, including:

> 'V' shaped glide paths

> dynamic lifecycle funds

> a new layered approach (target tracking, transition, market valuation, and mean reversion).

The layered approach to asset allocation tested in this report is based on the idea that investors should account for retirement income targets, their horizon relative to the retirement date (the transition-to-retirement phase), and sequencing risk through a valuation-sensitive investment approach.[4] Unlike the previous reports in this series, we are concerned in this study with providing insights into the challenge of asset allocation over the very long run (around 65 years). In the next section we consider issues from the institutional setting that inform our research agenda.

4 Sequencing risk is the degree of vulnerability to a negative sequence of returns when the portfolio's size is at its peak. Sequencing risk acknowledges that a given percentage change has an outsized impact on absolute wealth when the size of the portfolio is greatest.

2. INSTITUTIONAL SETTING

This section of the report may be read as a primer on some of the issues facing superannuants in Australia (and their fiduciaries). The motivation here is to consider the interplay between:

> the nature of defined contribution plans
> longevity
> asset allocation
> markets and mean reversion.

The interplay between these concepts is critical in understanding the competing approaches to asset allocation over the very, very long run and retirement outcomes considered in the analysis.

2.1 The nature of defined contribution plans

Defined contribution (DC) plans allow workers to accumulate wealth based on contributions made to the portfolio and the investment performance on the portfolio's assets over the working life of the member.[5] Much like a savings account, an individual's DC account balance is equivalent to the market value of assets accumulated in the account. In Australia, employees have substantial control over how the contributions to their superannuation plan are invested and can therefore choose from a number of asset classes (stocks, fixed income assets, real estate, etc.) and asset allocations.

While DC plans are typically portable between employers throughout an individual's career, they are subject to a range of risks borne by the plan member. These risks include:

> the risk of inadequate contributions (depending on contribution rate, periods of unemployment, etc.)
> investment risk, including sequencing risk (Basu et. al. 2012)
> unsustainable withdrawal rates during retirement or longevity risk (i.e. outliving portfolio wealth) (Drew and Walk, 2014).

Retirees who purchase annuities to manage longevity risk may also face (Poterba, 2006):

> interest-rate risk (e.g. retiring when interest rates are low may mean the annuity yields an income that is permanently low)
> inflation risk (particularly if a level annuity is purchased)
> income risk (particularly if an investment-linked annuity is purchased)
> credit risk (for instance, the risk associated with the annuity-provider's creditworthiness).

Also, DC plan members bear the risk of changes in the regulatory system (taxes, asset class investment restrictions), and as mentioned earlier, the risk unplanned expenses (e.g. health and aged care costs). Recent regulatory changes such as MySuper and competitive pressures (e.g. fund mergers) have seen superannuation funds innovate to attempt to manage some or all of these risks on behalf of plan members.

Notwithstanding the efforts of superannuation fund trustees, the long-term shift from traditional defined benefit pensions to DC investing places significant responsibility and challenges on retirees to successfully generate lifetime retirement income. Some of the key challenges include:

> *Life expectancy* — Dramatic improvements in life expectancy mean that the funds saved for retirement may need to last a long time (i.e. 20 to 30 years or more after retirement). Given the uncertainty around how long an individual retiree may actually live, many retirees are not prepared to manage this critical task on their own (see next section for further data).
> *Market events* — Investment risk complicates the challenge of managing a retirement portfolio during both the accumulation phase and the drawdown phase (Drew and Walk, 2014). For instance, since the 1980s there have been four significant market events that have, in some way, affected the capacity of retirees to manage their affairs. Since today's retirees are likely to live for at least 20 to 30 years beyond their retirement date, retirees must expect and plan to survive more financial volatility in the future.
> *Financial literacy* — Most of us simply don't know how to calculate the amount of retirement savings we will need to generate a desired retirement income in a way that sees us through our lives. Research has shown that many people struggle with portfolio selection decisions (Benartzi and Thaler, 1999, 2001). This can result in workers retiring too early, with too little saved, and without any buffer for contingencies during retirement (such as age-related health care or aged-care costs). Social security may provide a form of safety net but whether the age pension is adequate for most retirees to live on is debatable.

5 This is in contrast to defined benefit (DB) plan members whose pension benefits are instead based on formula which combines years of service and the worker's pre-retirement earnings profile.

- > *Inadequate planning and management* — A great deal of evidence suggests that retirees do a poor job of managing retirement risks. For instance, many retirees lack a formal plan to generate income from their savings, and many spend down their assets at an unsustainable rate. Other retirees greatly under-spend during their retirement for fear of running out of money, sometimes leaving significant wealth to their heirs. Both extremes represent an inefficient approach to managing retirement (Drew and Walk, 2014).

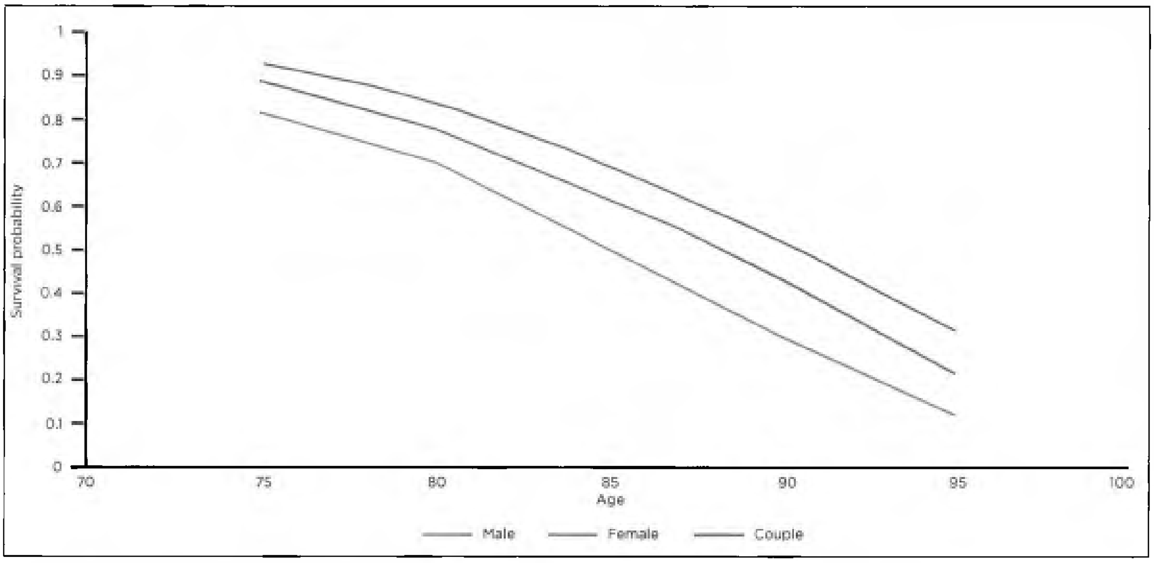
Financial advice is one way to address both the lack of financial literacy and inadequate planning but the use of financial advice by superannuation investors is not as widespread as one might hope given the complexity of the retirement planning problem. Given the challenges of increasing the take up of holistic financial advice, some market participants are developing or have developed new technologies (known as 'robo-advisors') that are specifically designed to assist with key parts of the financial planning process.

2.2 Longevity

It is important to quantify the metrics of longevity for existing and future retirees. Life expectancy is usually calculated from life tables using current age-specific death rates. The 'current' life table method is computed using the current rate of deaths per population between each exact age and each age plus one year. An alternative to this method is the cohort life table method where the death rate experience of birth cohorts is used (Armitage and Berry, 1994). Life expectancy at a particular age is represented as the probable mean length of additional life beyond that age of all people alive at that age if they are truly representative of the overall population. Life tables are produced based on a hypothetical starting population of 100,000 persons at exact age zero and ceasing at 99 years of age.[6] Since males and females experience different death rates, life tables are produced separately by gender. Deaths in each year reduce the population at the next age, and if plotted, produce a curve of 'survival'. Life tables are useful for comparing different populations as they standardise for different age structures.

For a 65-year-old Australian male alive today, there is around a 50 per cent chance he will live to the age of 85, a 30 per cent chance he will live to the age of 90 and a 12 per cent chance he will live to the age of 95. Similarly, for a 65-year-old Australian female there is a 50 per cent chance she will live to the age of 87, a 41 per cent chance she will live to the age of 90 and a 21 per cent chance she will live to the age 95. Most striking is that for a male and female couple, both aged 65, there is a 50 per cent chance that at least one will live until the age of 91 and a 31 per cent chance that at least one will live to the age of 95 (Knox, 2007; Association of Superannuation Funds of Australia, 2013; Australian Government Actuary, 2014). Almost one out of three retired couples will need income to sustain at least one of their household until the age of 95. Figure 2 illustrates these survival curves. Longevity risk, while well understood by many retirees, still presents a major concern for informing asset allocation strategies.

FIGURE 2: Survival curves for Australian men, women and couples



Source: Australian Bureau of Statistics (2013) and Australian Government Actuary (2014).

6 For Australian tables.

In considering these survival curves it is worth noting that they do not take account of future longevity gains. If future longevity gains are similar to those observed for the past century or so, planning based on these survival curves could significantly underestimate longevity risk.

2.3 Asset allocation

Observed investor behaviour reveals that most investors do not change the asset allocation of their retirement portfolio as their working life evolves, and many make no change even as new information on asset performance becomes available (Benartzi and Thaler, 1999). In the field of economics, scholars traditionally have framed decision making by rational agents using some form of utility function. According to this framework, investors seek a level of retirement wealth that maximises their utility (see Samuleson, 1969).

Conventional approaches to the problem of asset allocation ultimately seek to maximise portfolio wealth on the date of retirement for a given level of risk aversion. Retirees with high levels of risk aversion are advised to invest conservatively and purchase annuities or deferred annuities to offset longevity risk. Retirees with low risk aversion levels are generally advised to allocate a higher proportion of their portfolio to growth assets (stocks, real estate, exchange traded funds (ETFs), etc.) and the remainder to defensive assets (bonds and cash). Retirees with medium risk aversion levels are often advised to adopt a variant of the two. The aim in each case is to preserve wealth through retirement from which income is drawn, with the constraint that wealth shall not be depleted before death. Under this formulation, it is rare that the retirement goals and cash flow needs of retirees are considered and indeed, retirement income itself is seldom viewed as the key variable to optimise (Bianchi, Drew and Walk, 2013).

As mentioned earlier, research on the theory of asset allocation shows that both fixed and pre-determined glide path asset allocation strategies are optimal under certain conditions. In Samuelson (1969) and Merton (1969, 1990), the optimal investment strategy is independent of wealth and constant over time if:

> asset return distributions are independently and identically distributed (iid)

> the utility function of the investor adheres to constant relative risk aversion (CRRA)

> only investment income is considered (ignoring access to state pensions, home equity, etc.)

> there are no transaction costs (rebalancing assets and asset class liquidity are ignored).

Dynamic strategies may be optimal if any of the above conditions are violated. In general, and in most practical cases, the optimal investment strategy is necessarily dynamic to reflect the real-life behaviour of investors. Optimising wealth at retirement (or even, as some scholars insist, at death) is not a sufficient objective function. While maximising wealth at retirement is important, it is only necessary insofar as it simultaneously meets retiree cash flow needs through retirement, takes as much risk as is warranted, and protects against the probability of ruin.

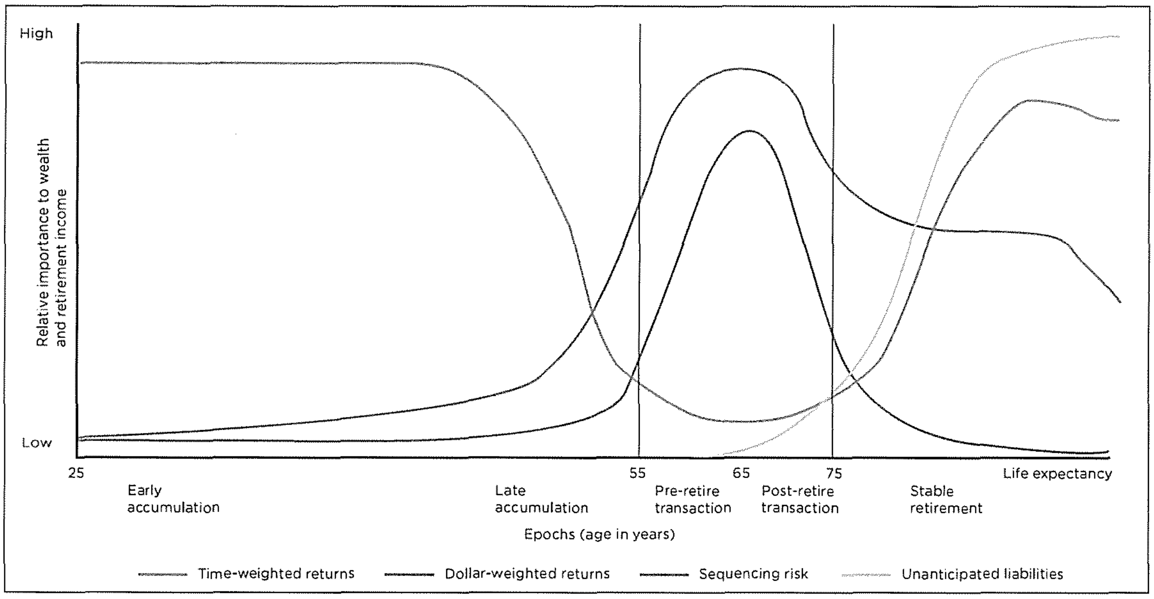
When retirees become more concerned about outliving their retirement portfolio than leaving an inheritance to their children, the optimal asset allocation strategy during retirement often shifts from a focus on wealth maximisation and a bias towards equities (as much as is tolerable to generate a greater average return), to strategies that look to preserve wealth under adverse economic scenarios. This shift obviously comes at the expense of upside returns when times are good.

There are a wide range of retirement asset allocation and product strategies focused on minimising spending risks, instead of wealth maximisation. These include the use of annuities with various guarantees, bucket strategies with cash reserves, and the 'rising equity glide path' strategy (Kitces and Pfau, 2014) that allocates portfolio wealth to conservative assets early in retirement and then becomes progressively more exposed to risky assets (i.e. equities) over time. The conservative assets (bonds and cash) finance spending during the early years of retirement. These sorts of approaches go part way towards addressing the possibility of long-term depressed markets as well as sequencing risk, but do so deterministically. The absence of a feedback mechanism in a strategy that only considers wealth subordinates both short- and long-term cash flow needs to some higher order risk measure.

Concerns over sequencing risk tend to drive behaviour towards risk minimisation strategies. However for some retirees, such strategies may be unnecessary because sequencing risk and its impact on retirement portfolios at a critical time never materialises. Investors therefore need to better understand whether they are exposed to the potential for a five or 10-year period of low or negative returns to predict when it becomes necessary to focus on risk minimisation strategies. The corollary to this is that it also allows investors to better understand when wealth maximisation strategies will generate the optimal retirement outcome.

Figure 3 highlights the relative importance of time-weighted portfolio returns, dollar-weighted portfolio returns, sequencing risk, and unanticipated liabilities during retirement (such as age-related health care and aged care costs) through the accumulation and retirement phases of an individual's life. During the early part of our working life time-weighted returns dominate all other concerns. Dollar-weighted returns and the threat of sequencing risk grow in importance as we near the Retirement Risk Zone. At the retirement date, dollar-weighted returns as well as capital preservation become important. As the individual enjoys their retirement, the threat of unexpected expenditures emerges so dollar-weighted returns dominate other concerns. As longevity risk emerges late in retirement, time-weighted returns may come to dominate other concerns, except perhaps for the continued threat of unexpected expenditures. Bequests also become an important consideration during the late retirement phase. The complex interplay of these risks through the stages of an individual's working life and retirement suggests that a simple glide path strategy is insufficient for dealing with the investment problem.

FIGURE 3: The relative importance of factors that contribute to retirement outcomes



The maximisation of wealth on the date of retirement as the objective function ignores the 20 to 40 year investment horizon most retirees face. Such an approach also ignores the relative value of defensive and growth assets over such a long horizon.

Consider the following example. Say you retired exactly 20 years ago in 1995. Over this period your retirement portfolio would have endured the tail end of a long recession, a substantial liquidity crisis courtesy of LTCM, the Asian Financial Crisis, the dot-com boom and bust, the mining boom, the global credit crisis, the European debt crisis and the recent slowing of economic growth in Australia. If your portfolio was valued at $400,000 on your retirement date, and you withdrew a relatively frugal $3,000 per month (indexed to inflation), your portfolio would be represented in Figure 4, for a range of asset allocation strategies. If you switched to a conservative portfolio on the date of retirement you would have around half of your portfolio remaining today. If you invested the entire portfolio in stocks, you would have more money today than when you started. If you invested half in stocks and half in bonds, you would have around the same amount today as when you started. These strategies remain ignorant of market behaviour and relative asset values, and simply assume you will withdraw the same income of $3,000 (in real terms) month after month.

But what if you used a relative market valuation metric as a guide for whether to invest in growth or defensive assets? There have been several attempts to implement 'market-aware' metrics to guide strategic asset allocation. These include the use of

> wealth ratios (Lettau and Ludvigson, 2001)

> adaptive macro indexes (Bai, 2010)

> the sum of macro variables (Ferreira and Santa-Clara, 2011)

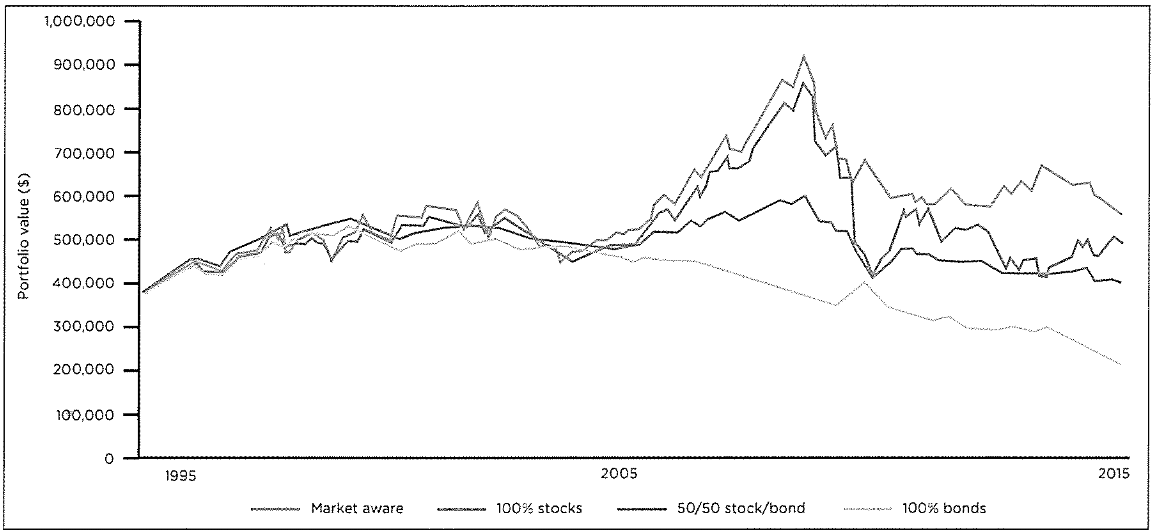
> implied cost of capital (Li, Ng and Swaminathan, 2013)

> factors relating to the price of oil (Kilian and Park, 2007)

> the current PE ratio relative to the historical average (Shiller, 2000).

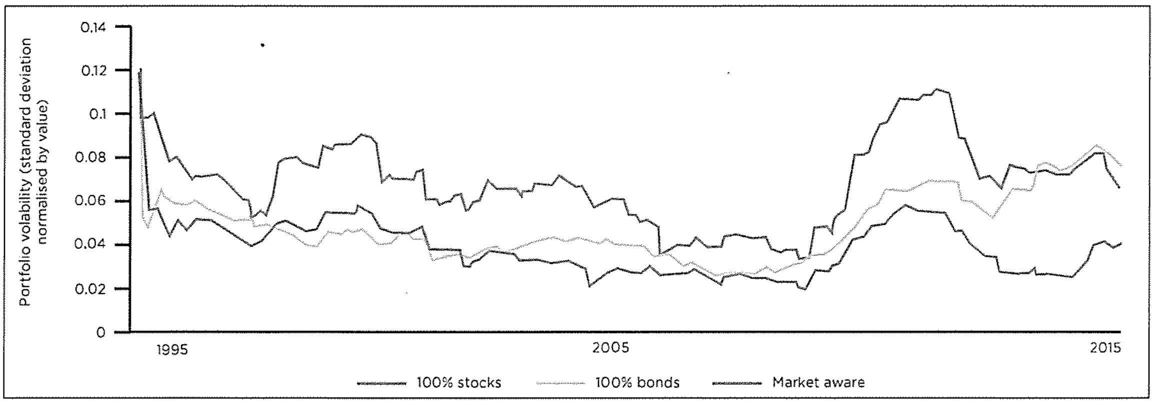
The metric that has been shown to be robust and remains credible under almost all conditions is Shiller's historical price-to-earnings (PE) ratio.[7] This simple ratio is represented as current price divided by the average of ten years of earnings adjusted for inflation. This is a 'market aware' valuation strategy that explicitly takes account of when the stock market is over-valued or under-valued relative to the historical average. By using an upper market PE threshold of 24 and a lower market PE threshold of 14 as a decision tool that dictates whether we switch our entire portfolio out of, or into, stocks respectively, we find that the portfolio earns substantially more than the alternative naïve strategies. The upper line profile in Figure 4 illustrates its performance relative to the baseline strategies. But this is only half the story.

FIGURE 4: Portfolio value of alternative investment strategies for a retiree commencing in 1995 with $400,000 in savings and a monthly withdrawal of $3,000 indexed to inflation



More importantly, the volatility of the portfolio is lower than all of the baseline (naïve) strategies. Figure 5 illustrates that the normalised portfolio standard deviation (using a moving window of 24 months) exhibits lower variability than the 100 per cent stocks (as perhaps expected) and 100 per cent bonds options (as perhaps not expected). In fact, the volatility is lower than all naïve combinations of stocks and bonds over this period. The variability in Figure 5 is normalised by portfolio value to give a better indication of movements relative to actual portfolio value.

FIGURE 5: Portfolio standard deviation (24-month window) normalised by value of alternative investment strategies for a retiree commencing in 1995 with $400,000 in savings and a monthly withdrawal of $3,000 indexed to inflation



7 Yale University professor Robert Shiller presented an argument demonstrating how stock markets can be assessed as either overvalued or undervalued in his book *Irrational Exuberance* first published in 2000. The stock market collapse of 2000 happened the exact month of the book's publication. The second edition published in 2005 was updated to cover the housing bubble.

This simple, very stylised, illustration of the role of market-awareness in asset allocation decisions provides the rationale for its inclusion in this report. As with all these types of analyses, it is important to stress that the 20-year window used in this example represents only one possible retirement portfolio path. This result alone cannot be used to justify the wholesale use of market-aware asset allocation decisions for all circumstances. However it does serve as a prompt for us to investigate the possibility of using relative asset valuations as a basis for intelligent investment decision-making, particularly during the critical Retirement Risk Zone where portfolio wealth is at its zenith.

2.4 Markets and mean reversion

Many traditional economic models for evaluating future equity market returns are based on arguable assumptions.[8] Basing predictions on the earnings growth of companies, which in turn are derived from the economic metrics of its host nation, and then extending this to estimate equity returns using relative market valuation techniques, can be perhaps be described as heroic. At best, a rough forecast can be made for economic fundamentals (GDP growth, inflation) which can be translated into a narrow forecast of corporate expectations. The earnings profile of multinational companies, which tend to dominate equity index composition, are increasingly decoupled from national or regional economic trends, and earnings growth is correlated weakly with the equity market development in the medium term (Carrieri, Errunza and Sarkissian, 2012).

While many of these issues remain contested, investors have explored whether market valuation measures can offer guidance to inform the asset allocation glide path both to and through retirement (e.g. Okunev, 2014; Estrada, 2014). While acknowledging that most, if not all, such approaches are open to critique, we are motivated in this report to consider the merits (or otherwise) of a dynamic approach to asset allocation decisions as they relate to retirement investing. In this analysis, we introduce a dynamic approach as an alternative to deterministic (or static) asset allocation frameworks. Specifically we consider whether it is beneficial to adjust equity exposure dynamically based on market valuations from year to year throughout both the accumulation and retirement phases. That is, we consider the merits of competing asset allocation approaches to retirement outcomes over the very, very long run (some 65 years).

As part of the broader research question, there is evidence to suggest that sequences can at least be partially predicted by long-term valuation measures. One well-known measure which was mentioned earlier is the cyclically adjusted price-to-earnings ratio, commonly known as the Shiller CAPE[9] or the P/E 10 ratio. This measure is defined as the current price for a stock divided by the inflation-adjusted average of ten years of earnings (Campbell and Shiller, 1988). The metric has been used to form a view about equity returns over the coming 10 to 20-year period: higher than average CAPE values imply lower than average long-term annual average returns (Shiller, 2000) and vice versa. It is not a reliable leading indicator of impending market crashes, although high CAPE values have been associated with such events. While the measure is a poor predictor of short-term performance and will not aid with market timing, it may help predict long-term performance when used prudently as an asset allocation tool. If the Shiller CAPE measure can help predict the danger of an extended sequence of bad market returns, it could also be employed to help define the asset allocation glide path over the retirement transition period.

Figure 6 illustrates the 10-year annualised future returns against the Shiller CAPE ratio for Australia, 1890–2004, segmented into epochs. Apart from the 1920–1940 period, a general inverse relationship between Shiller's CAPE and subsequent stock returns generally holds in the Australian context. Figure 7 illustrates the Australian stock value index relative to periods when the CAPE suggests stocks are overvalued (shaded periods). Plateaus in stock values (represented by horizontal black lines) emerge during and immediately after each period that experiences high CAPE values.

8 For instance, assumptions regarding the timeframe over which valuations return to normal are hotly contested. Is this period five years? Seven years? Or is the period a non-constant number of months or years? We know these issues are very difficult to resolve on an ex-ante basis.

9 The measure is named after the same Robert Shiller mentioned earlier, who popularised the 10-year version of Graham and Dodd's five-year P/E (Graham and Dodd, 1951).

FIGURE 6: 10-year annualised future returns against the Shiller CAPE ratio for Australia, 1890-2004

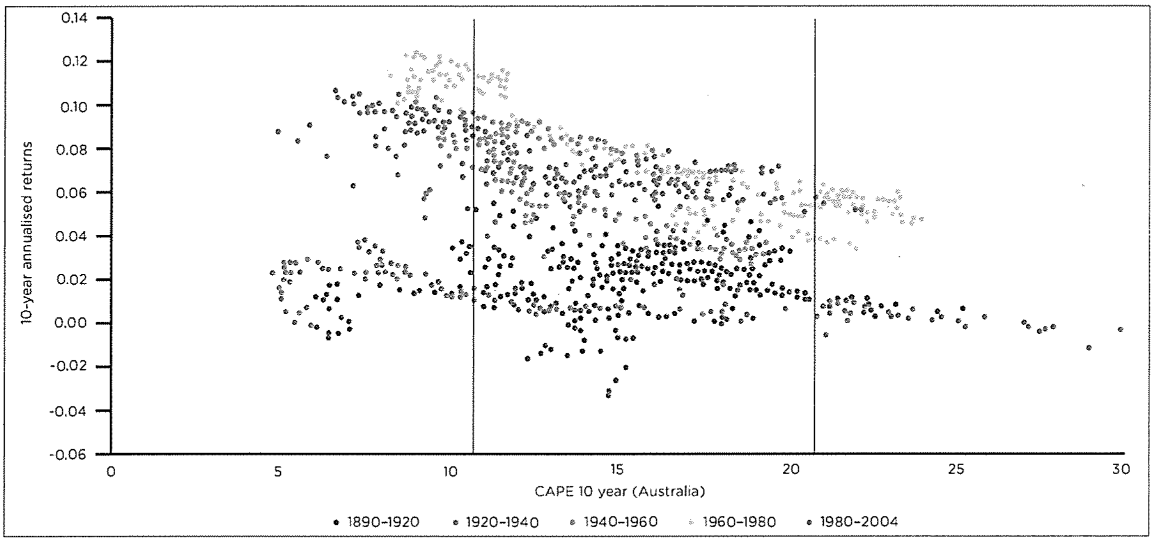
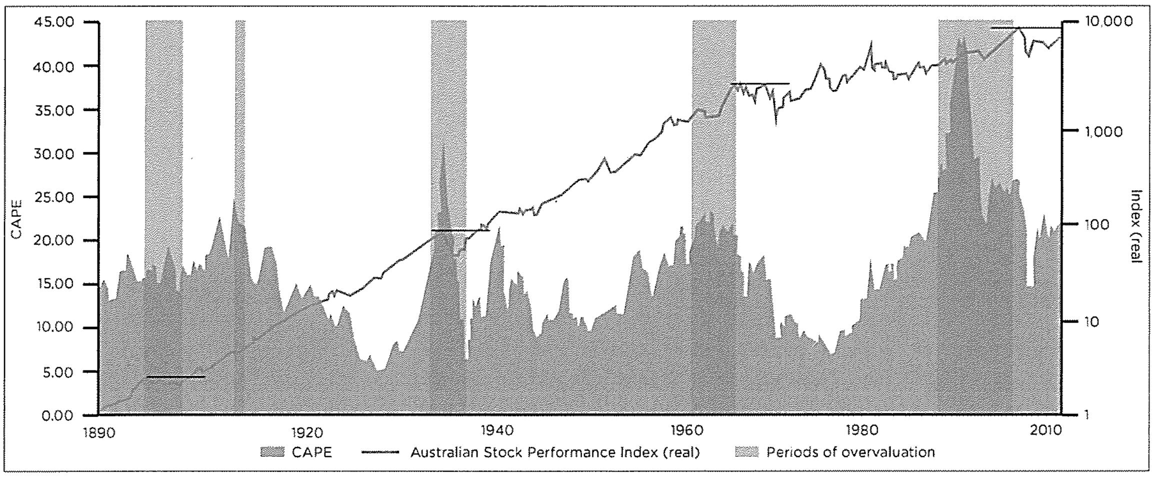


FIGURE 7: Time series of CAPE (Australia) and inflation-adjusted S&P/ASX 200 Accumulation Index (in AUD) over the period 1881-2013



NB: The blue columns indicate overvaluation phases where CAPE > 18. Horizontal black lines show the plateau in stock values that emerges during and/or immediately after each period of high CAPE values.

The Shiller CAPE measure has its share of critics who argue that the earnings component of CAPE is far too low. For instance, Jeremy Siegel has argued new accounting standards place a downward bias on earnings (Siegel, 2013). He further claims that the CAPE ratio generates overly pessimistic predictions which are based on biased earnings data because changes in the accounting standards have forced companies to impair assets that have fallen in value but are not permitted to revalue assets upwards when their values rise. These assets therefore do not contribute to earnings unless they are sold.

It is important to examine the mechanics of the underlying measure in order to judge its applicability for predicting equity market reversions to the mean. The Shiller CAPE approach uses GAAP earnings per share (EPS) for the entire time series.[10] Others have suggested augmenting GAAP EPS early in the time series with operating EPS or pro-forma EPS metrics (Ro, 2014). The advent of goodwill and asset impairments[11] has naturally caused GAAP EPS to understate the 'fair' EPS. In addition, there is also concern over the use of inflation-adjusted historical EPS. Adjusting for inflation only, while necessary, may underscore the impact of changes in the dividend payout ratio observed in the market. This adjustment would be difficult to achieve in practice owing to the tax incentives surrounding the choice between dividends and stock buy-backs, particularly in Australia. Nevertheless, some version of the Shiller CAPE metric can be applied for the Australian equity market to judge the sensitivity of a heavy allocation towards equities, especially during the Retirement Risk Zone.

Having now provided some necessary background on the interplay between key issues that motivate the analysis, we now turn to the report's methodological approach.

10 Generally Accepted Accounting Principles (GAAP) refers to the standard framework of guidelines for financial accounting.
11 This outcome is largely due to the elimination of pooling accounting for mergers and the regular impairment test of acquired goodwill.

3. INVESTMENT ELEMENTS AND METHODOLOGY

What is the best way for investors to construct a portfolio that combines both growth and defensive assets, and then change the composition as investors move through their life cycle, in order to finance their retirement? We consider various extant designs that are used in the market today (such as TDFs) through to current innovations in the lifetime asset allocation debate, including: V shaped glide paths; dynamic lifecycle funds; and a new layered approach (target tracking, transition, and market valuation).[12]

Research has consistently shown that asset allocation is the primary decision variable for investors (Brinson, et. al. 1986). Given that equities dominate the risk budget of most portfolios, this fact can be reduced further:

How much of my retirement portfolio should I allocate to equities in the following phases?

> early accumulation
> late accumulation
> Retirement Risk Zone
> early retirement
> late retirement.

The relative importance of time-weighted returns, dollar-weighted returns, sequencing risk, longevity and unanticipated liabilities will drive this decision (refer to Figure 3 in the previous section). As well as testing various extant designs (such as TDFs), we also consider the merits (or otherwise) of a systematic layered approach to the asset allocation decision, based on all of the key inputs that affect this decision. These inputs include:

> salary (and salary growth)
> expected retirement income
> investment horizon (including retirement date)
> life expectancy (which many retirees already have an intuitive idea of).

We test various asset allocation approaches through all phases of our hypothetical investor's working life and retirement. After all, workers see their life as a continuous stream of income (through the realisation of human capital), investment wealth (in the form of returns on savings) and the associated liabilities, rather than a discrete set of investment phases.

To model investment behaviour through both the accumulation phase and the retirement phase, and to derive both the optimal asset allocation strategy and the optimal retirement income, some form of dynamic programming is necessary. For serially independent asset returns, general utility, and no transaction costs, a stochastic dynamic programming recursion is effective and efficient. This approach can provide some insight into the capacity for dynamic strategies to minimise sequencing and longevity risk. However the results will only be approximate and the sensitivity of outcomes will be largely contingent on the volatility of the underlying assets. For general serially dependent asset returns and the consideration of transaction costs, as is observed in the market, a multi-stage stochastic programming approach is needed.

Here we examine four strategies, each of which attempts to represent an approach to allocating assets that has been employed in the DC systems around the world. The first strategy is a simple target date fund (TDF1) strategy. The TDF1 strategy invests heavily in growth assets for up to 30 years following the commencement of superannuation contributions. The strategy then linearly switches from growth to defensive assets over the remaining years to retirement such that at the point of retirement the majority of wealth is invested in defensive assets. The allocation remains defensive in nature through retirement. This type of allocation is typical of lifecycle or target date strategies used in practice.

The second strategy (TDF2) is similar to the TDF1 strategy in that it also adopts an increasingly defensive asset allocation as the retirement date approaches. The key difference is that it incorporates the findings of Kitces and Pfau (2014) by linearly switching out of defensive assets into growth assets through retirement. TDF2 is therefore an example of a V-shaped glide path.

The third and fourth strategies adopt variants of the dynamic lifecycle (DLC) approach of Drew et al. (2014b). Because each dynamic asset allocation strategy requires context they are discussed below in further detail with reference to the layers of the investment plan.

12 Using market data, we investigate four strategies. We are specifically interested in whether a simple, replicable dynamic asset allocation strategy yields superior outcomes not only in terms of absolute wealth, but also in improving the sustainability of income in retirement. Using a layered approach, individualised investment strategies can be designed based on retirement objectives. At a more detailed level, these strategies are a function of the relationship between required and target wealth levels, the investment horizon of the investor, and relative market valuation.

3.1 The first layer — target tracking

Target tracking strategies are defined as those that are conditional on the attainment of a plan member's wealth accumulation objective. They are loosely classified as dynamic lifecycle strategies and have been shown to be highly effective relative to static strategies for reaching retirement wealth objectives (Basu, Byrne and Drew, 2011).

Dynamic lifecycle strategies, identified here as target tracking, are responsive to past performance of the portfolio relative to an investor's target return in determining the mix of assets in future periods. Switching to conservative assets takes place only if the investor has accumulated wealth in excess of a target accumulation at the point of switch. After switching to conservative assets, if accumulated wealth falls below the target in any period, the direction of the switch is reversed by moving away from bonds and cash towards stocks. The use of a wealth accretive target during an investor's accumulation phase helps define the need to switch between conservative and risky assets to reach a wealth objective (e.g., 9 per cent per annum compounded return for 30 years).

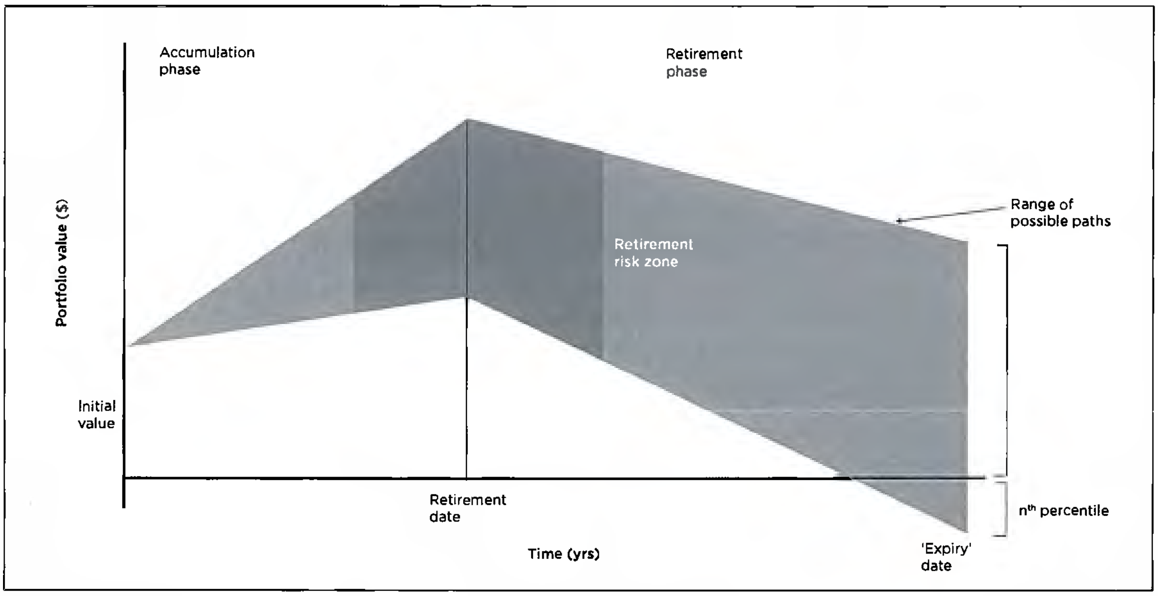
In this analysis, we employ two dynamic lifecycle strategies for an investor over both the accumulation and retirement phases. During the accumulation phase the dynamic strategies have the same asset allocation as the TDF strategies until 20 years prior to the investor's predicted retirement date. Each year after this point, the strategy reviews how the portfolio has performed relative to the investor's accumulation objective. If the value of the portfolio at any point is found to equal or exceed the investor's target, the portfolio partially switches to conservative assets. Otherwise, it remains invested 100 per cent in stocks. If the switch to conservative assets has begun and the cumulative performance drops below target, the fund is switched back into growth assets. The dynamic lifecycle strategy uses performance feedback to determine the asset allocation at any point in time while typical static or lifecycle strategies do not.

Specifications regarding the targets used in this study are provided in Section 3.4. Moreover, all strategies are outlined in detail in Section 3.5.

3.2 The second layer — retirement risk zone

For the purposes of this report, the retirement risk zone is defined as the final five years of working life (the 'accumulation' phase) and the first five years of retirement (the 'decumulation' phase). Importantly, it is this 10-year period when the greatest amount of retirement wealth is in play and, therefore, risk is at an all-time high (Figure 8). Workers near or at retirement are at risk from two related phenomena: the portfolio size effect (wealth is at its zenith), and sequencing risk. Basu and Drew (2009a) find that, due to the positive compounding effect of salary growth, contributions and returns, portfolio size grows rapidly in the latter half of a worker's accumulation phase. When the portfolio size effect is combined with an unfavourable sequence of returns (Macqueen and Milevsky, 2009) the impacts can be both extreme and irreversible.

FIGURE 8: Retirement Risk Zone relative to portfolio value



In the first of Finsia's papers about the Retirement Risk Zone, Doran et. al. (2012) find that the sequence of returns materially impacts the terminal wealth of superannuants, and heightens the probability of portfolio ruin. In fact, sequencing risk can deplete terminal wealth by almost a quarter while simultaneously increasing the probability of portfolio ruin at age 85 from one-in-three to one-in-two.

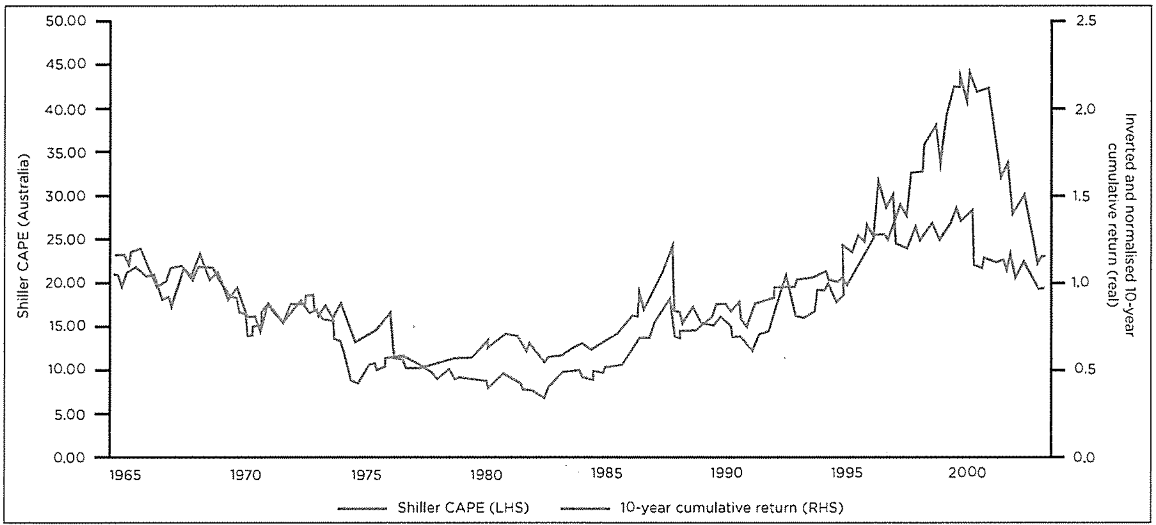
As a response, in this study, when the investor enters the Retirement Risk Zone the portfolio is automatically shifted towards more defensive assets, unless the investor is both below the target accumulation level and the market valuation metric for stocks is favourable.

3.3 The third layer — market valuation and mean reversion

The third layer influences asset allocation by reference to whole-of-market valuation techniques. In this analysis we use the Shiller CAPE (discussed earlier) to evaluate market value conditions which in turn feed into the asset allocation decision. [Recall, Figures 6 and 7 illustrate the quantitative evidence pointing to long-term trends in market values.]

To appropriately categorise market return expectations, we divide the market value predictor into three groups: (1) overvalued markets, defined as years in which the Shiller CAPE is equal to or greater than 1.25 times the historical average; (2) undervalued markets, defined as years in which the Shiller CAPE is equal to or below 0.75 times the historical average; and, (3) neutral markets, defined years in which the Shiller CAPE is between the 0.75 and 1.25 times historical average thresholds.[13] This corresponds to a Shiller CAPE between 11 and 21. Figure 9 illustrates the current Shiller CAPE and ten-year real stock market returns for Australia.

FIGURE 9: Shiller CAPE and ten-year real stock market returns for Australia, 1965–2004



3.4 Setting the accumulation target

We can set the retirement accumulation target in one of two ways. First, a simple target value based on history and future expectations can be set. Dimson, Marsh, and Staunton (2002), for example, have compiled returns for US stocks, bonds, and bills from 1900. We take an updated version of their dataset and find the geometric mean return offered by US stocks between 1900 and 2004 is 9.69 per cent (Dimson, Marsh and Staunton, 2008). We might assume that the individual sets a target of achieving a return on the retirement plan investments close to this rate, say 10 per cent. In other words, the retirement portfolio under the dynamic strategy aims to closely match the compounded accumulation of a fund where contributions are annually reinvested at a 10 per cent nominal rate of return.

The second approach is more complex and involves reverse-engineering a portfolio value at retirement based on an assumed dataset, a required annual income drawn from the portfolio, and an assumption on individual mortality. We simulate a number of possible paths forward from the date of retirement, accounting for withdrawals and portfolio returns, and iteratively solve for the optimal income withdrawal at a given confidence level. This method is described in more detail below.[14]

13 These thresholds are based on the Graham and Dodd (1951) investing rules. This methodology predates the Shiller CAPE and represents rules of thumb used in the application of the relative market valuation approach to asset allocation.

14 Readers who are comfortable with simply assuming an arbitrary accumulation target as defined above can safely move to the next section without fear of understanding the more complex approach to accumulation targets.

This model assumes that the retiree begins retirement with an initial withdrawal from their retirement portfolio and the post-withdrawal portfolio is invested in stocks, bonds and cash. The portfolio earns an inflation-adjusted rate of return, earned initially from a constant asset allocation, until the next annual withdrawal. A discrete time representation of the portfolio rate of return is:

$$r_t^i = \sum_{j=1}^{n} w_{t,j} r_{t,j}^i, \quad (1)$$

where r_t^i is the weighted average portfolio return for simulation *i* at time *t*, $w_{t,j}$ is the portfolio proportion assigned to asset class *j* at time *t* and $r_{t,j}^i$ is the annual inflation-adjusted return for asset *j* at time *t* for simulation *i*. Ongoing withdrawals remain the same inflation-adjusted amount from the portfolio (in inflation-adjusted dollars), and the value of the portfolio is derived as:

$$V_t^i = \left[V_{t-1}^i - MV_0\right]\left(1 + r_t^i\right), \quad (2)$$

where *V* represents the value of the portfolio and *M* is the constant withdrawal fraction amount.

We use stochastic optimisation in the model to identify the optimal withdrawal rate for a set of asset allocations and a known investment horizon that minimises the probability of portfolio ruin. We use the stochastic optimisation process to derive optimal withdrawal rates for the retirement phase. Prior to retirement we incorporate annual cash flows into the accumulation account up to the nominated date of retirement as well as initial portfolio conditions. The portfolio value V_t at time t is defined as:

$$V_t = (V_{t-1} + CF_{t-1})(1 + X_t) - LS_\tau + 1_E(SSP_{t>\tau}); \;\; t, \tau < T, \quad (3)$$

where CF_t is the after-tax cash inflow (positive) or outflow (negative), X_t is the weighted average portfolio return $w_n' r_n$ at time *t*, LS_τ is any lump sum payment withdrawn at retirement date τ and $1_E(SSP_{t>\tau})$ is an indicator function where 1_E is equal to one if the investor qualifies for social security payments (SSP) during retirement $t > \tau$ and zero if the investor does not qualify for such payments. Both the retirement date τ and the withdrawal dates *t* are assumed to be less than the terminal date *T* for all payments as selected by the investor. The value V_t of the portfolio at *t=0* is set to the initial portfolio value of the investor.

In contrast with deterministic approaches to retirement planning, where both the investment horizon and the investment return are assumed to be known with certainty, in this analysis we represent the variables as stochastic. We derive the stochastic present value at either the date of retirement (which assumes a deterministic terminal portfolio value) or at any point before retirement as:

$$\widetilde{PV} = \sum_{i=1}^{\tilde{T}} \prod_{j=1}^{i} \left(1 + \tilde{r}_j\right)^{-1}, \quad (4)$$

where $\tilde{T}$ is the random time of death (in years) and $\tilde{r}_j$ is the random investment return in year *j*. As $\tilde{T} \to \infty$ the stochastic PV simply reduces to the infinitely-lived endowment (Milevsky, 2006). The frequency of the above measure can be reduced to quarters or months as required without loss of generality.

The simulation process in this model assumes $\tilde{T}$ is fixed and is estimated by the investor (90 years of age in our case, but any mortality assumption is valid). This greatly simplifies the simulation and optimisation process. The asset values and projections are simulated 10,000 times and the key percentiles at each time *t* are estimated from the simulation. A range of percentiles are extracted from the simulated terminal values (at time *T*) for the investor's portfolio and then used as the future value to iterate backwards to retirement date τ. To conduct the search we use a simple generalised reduced gradient search algorithm (Lasdon et al. 1978) to solve for the annual withdrawal over the withdrawal period ($\tau \to T$), which is also simulated 10,000 times to achieve convergence. This method is sufficiently robust to find at least a local optimum where the function is continuously differentiable. This approach is also known to be robust relative to other nonlinear optimisation methods.

The algorithm needs input function values as well as the Jacobian, which we do not assume to be constant for our nonlinear model. We approximate the Jacobian using finite differences re-evaluated at the commencement of each major iteration (i.e. the major percentile terminal values).

Fundamentally, the simulation estimates the range of outcomes for an investor through both the accumulation and retirement phases. The stochastic optimisation process aims to select a constant withdrawal rate through the retirement phase that yields an expected terminal wealth of zero at a 10 per cent confidence level coinciding with the investor's 'expiry' date (death or other nominated future date). The Box Method (Box, 1965) iteratively searches possible input values for withdrawal amounts to equate the simulated probability of ruin at a 10 per cent confidence level, to find a global minimum solution (if one exists).

The objective function is thus:

$$\max(CF_t) \text{ subject to } Pr[V_T > x] := 0.10 \; : \; \forall \, t, \tag{5}$$

where x is set to zero for each and every period $t \in [0, T]$.

Intuitively, this approach allows the investor to focus on a level of income at a given confidence level. This avoids the perhaps more hopeful approach of setting the objective function to maximise wealth at the date of retirement and then draw down income and assume that the portfolio value is sufficient for the investor to not outlast their portfolio. Indeed, the intention of goals-based investing is to match the time-weighted value of assets and liabilities that cater for cash flows through an investor's working life as well as through retirement.

3.5 Simulation methodology

Simulations are useful in situations where there is a belief that something sensible can be stated about the factors that affect a problem, but when these factors are grouped together, the exact outcome is unknown. The range of factors that affect retirement outcomes including asset allocation, financial market performance, retirement date, salary growth rates, inflation, longevity, housing equity, pension withdrawals and unexpected costs during retirement, as well as many other factors, dictate that no single mathematical representation can adequately capture the overall result. It is important not to take shortcuts however, and to use as much empirical data as possible to adequately represent actual market behaviour (while remembering that, no matter how much data is thrown at the problem, the future remains uncertain). In this analysis, we employ actual asset returns, observed salary growth rates, observed and forecast inflation rates and observed pension withdrawal rates to lend the highest degree of reality to the simulation outcomes.

The block bootstrap is the most efficient approach when model residuals are correlated. Simple bootstraps or other forms of residual resampling will fail because they are unable to replicate the correlation in the data. The block bootstrap replicates the correlation by resampling blocks of data. We follow the block bootstrap process articulated in Ruiz and Pascual (2002) and Künsch (1989). Based on experience in using the block bootstrap approach outlined in Drew and Walk (2014b) we employ a block length of 36 months for the simulation. We simulate the data at a monthly frequency.

We simulate across our four investment strategies. The four strategies are as follows:

TDF1

Asset allocation remains at the initial level until 10 years prior to retirement date.

> at retirement date minus 10 years the plan switches to 60 per cent stocks and 40 per cent bonds

> at retirement date minus five years the plan switches to 30 per cent stocks and 70 per cent bonds

> at retirement date and beyond the plan switches to 30 per cent stocks 60 per cent bonds and 10 per cent cash and remains at this allocation through retirement.

TDF1 is a reasonable approximation of the sorts of glide path strategies available in DC plans throughout the world.

TDF2

Asset allocation is the same as for TDF1 except that five years after the retirement date it reverts to 40 per cent stocks and 60 per cent bonds. At retirement date plus 10 years the strategy switches to 50 per cent stocks and 50 per cent bonds and increases the allocation to stocks by 5 per cent every five years thereafter.

TDF2 is a type of V-shaped glide path.

DLC1

Asset allocation follows the same glide path as for TDF2 except an allowance is made for the use of dynamism to ensure that an accumulation target is met.

The DLC1 strategy invests in a 100 per cent stocks portfolio for 20 years and assumes that the individual sets a target of 10 per cent (compounded) annual rate of return on investment for this initial 20-year period. At the end of 20 years, if the actual accumulation in the retirement account exceeds the accumulation target, the assets are switched to a more conservative growth portfolio comprising of 80 per cent stocks and 20 per cent fixed income (equally split between bonds and cash). However, if the actual accumulation in the account is found to fall below the target, the portfolio remains invested in 100 per cent stocks.

Performance of the portfolio is reviewed annually for the next 10 years and the asset allocation is adjusted depending on whether the holding period return is greater or less than the target, which remains set at a 10 per cent annualised return on a cumulative basis. In the final 10 years of the accumulation phase the same allocation principle is applied with one difference. If the value of the portfolio in any year during this period matches or exceeds the investor's target accumulation (i.e. 10 per cent annualised cumulative return), 60 per cent of assets are invested in equities and 40 per cent in fixed income (equally split between bonds and cash). Failing to achieve the target return for the holding period, results in all assets being invested in the 100 per cent stocks portfolio. The above-target asset allocations in the retirement phase match those for TDF2.

DLC1 allows us to understand the benefits (or not) of being dynamic in pursuit of a target *based purely on a pre-set decision rule*.

DLC2

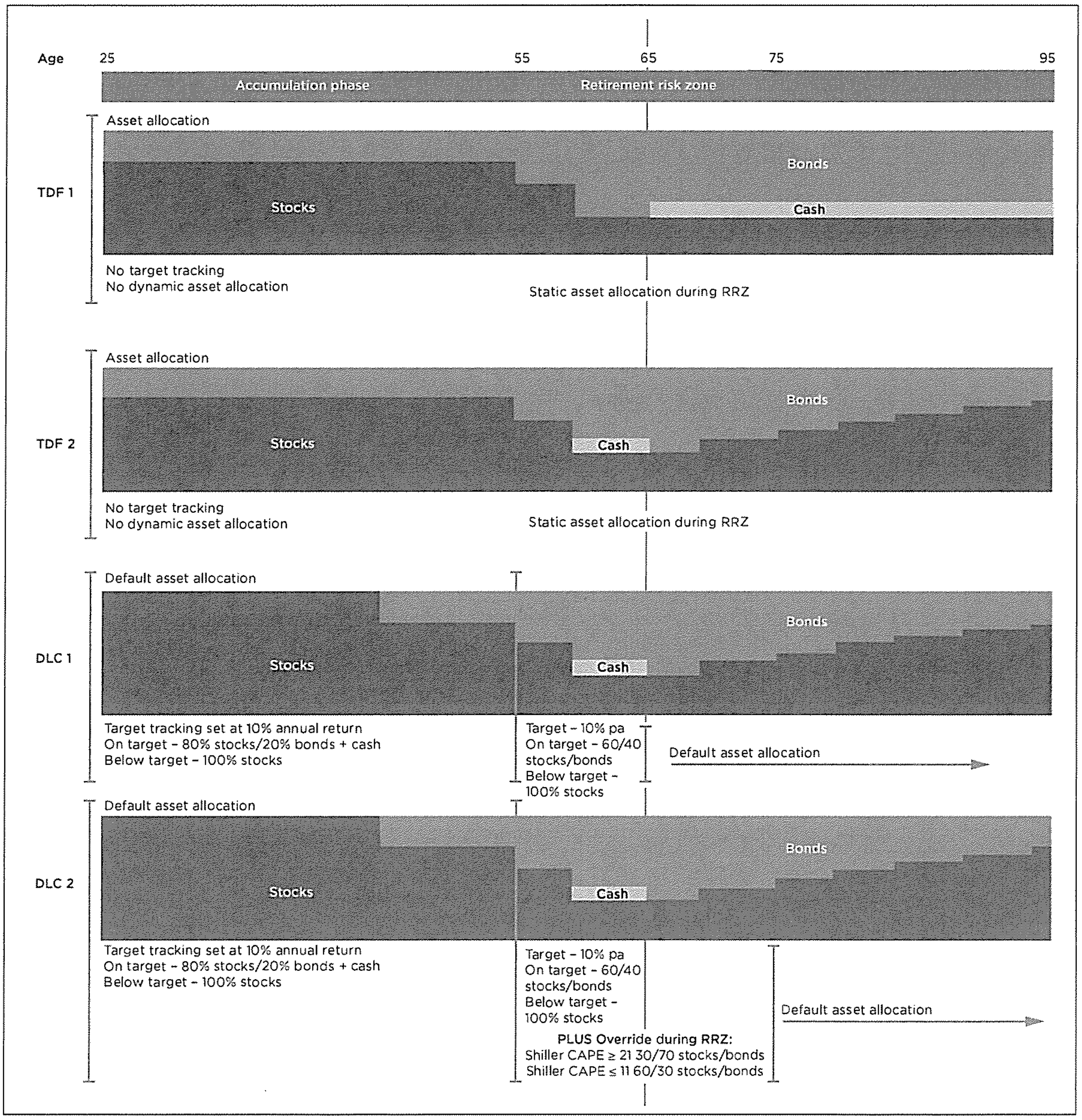
The strategy is essentially the same as DLC1 in that a dynamic asset allocation approach is employed to ensure that an accumulation target is met. The further addition to this strategy is the relative market valuation factor measured using the CAPE methodology only is applied during the Retirement Risk Zone period.

If the CAPE is equal to or above 21, we assume the market is relatively overvalued and reduce the allocation to growth assets to 30 per cent during the Retirement Risk Zone. If the CAPE is equal to or below 11, we assume the market is relatively undervalued and increase the allocation to stocks to 60 per cent during the Retirement Risk Zone. If the CAPE is between 11 and 21 the allocation to stocks remains fixed at 40 per cent.

Note that these upper and lower limits are arbitrary and can be altered to reflect the relative valuation view of the portfolio manager or investor.

DLC2 allows us to investigate the potential benefits of being dynamic in achieving a target based on *both* a pre-set decision rule *and* current market valuations.

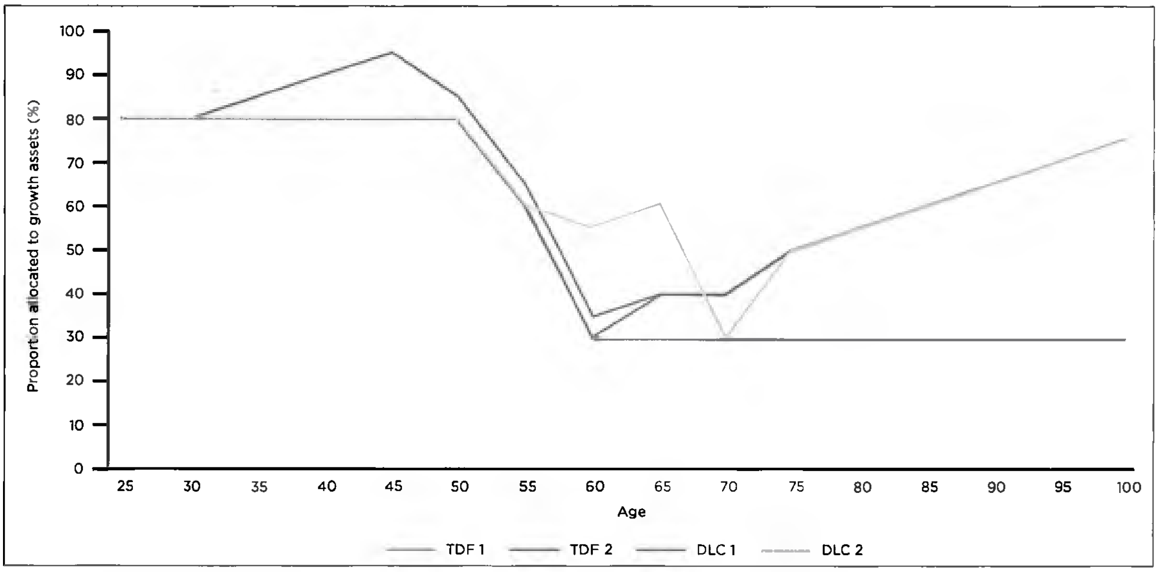
FIGURE 10: Sample strategy profiles for TDF1, TDF2, DLC1 and DLC2 strategies



NB: The DLC1 strategy maintains flexible allocation during accumulation up to the point of retirement while the DLC2 strategy maintains a flexible allocation during both accumulation and the retirement risk zone.

Sample strategies are illustrated in Figure 11. Note that the DLC2 strategy is a more flexible version of the DLC1 strategy, allowing the asset manager to switch in/out of growth assets if the market values of growth assets are greatly under- or over-valued respectively, relative to historical CAPE measures.

FIGURE 11: Sample glide paths of TDF1, TDF2, DLC1 and DLC2 strategies



NB: The DLC1 strategy maintains flexible allocation during accumulation and while the DLC2 strategy maintains a flexible allocation during both accumulation and the retirement risk zone.

Because, by definition, the DLC strategies are dynamic, the glide paths shown are sample glide paths based on a given set of returns. If we were to repeat this analysis, the allocations for the DLC1 and DLC2 strategies would be different because both would be dynamically responding to a different set of simulations.

4. DATA AND CALIBRATION

To overcome concerns relating to insufficient data we adopt a block bootstrap resampling simulation approach. The empirical monthly return vectors for the three asset classes in the dataset are randomly resampled in 36-month blocks with replacement to generate asset class return vectors for each month of the accumulation and withdrawal investment horizon confronting a retirement plan investor. Since we randomly draw blocks of rows (representing 36 months) from the matrix of asset class returns we retain both the cross-correlation between the asset class returns and serial correlation within asset classes observed in the historical data. As the resampling is done with replacement, a particular data point from the original data set can appear multiple times in a given bootstrap sample. This is particularly important when trying to anticipate the probability distribution of future outcomes.

Asset class return data for the block bootstrap was obtained from Global Financial Data (GFD). The S&P/ASX 200 Accumulation Index (in AUD) return series is used to represent Australian stocks while the S&P 500 Total Return Index w/GFD extension (in AUD) return series was used to represent foreign stocks. The 10-year Government Bond Return Index (in AUD) returns series was used to represent Australian bond data and the Total Returns Bills Index (in AUD) is used to represent Australian cash returns. We collated and synchronised the data to derive a series of monthly returns from October 1882 to December 2013. The summary statistics for the monthly data is provided in Table 1.

TABLE 1: **Summary statistics (nominal) for monthly return series of Australian stocks, foreign stocks, Australian bonds and Australian bills, October 1882–December 2013**

	Australian equities	Overseas equities	Australian bonds	Australian cash
Mean	1.01%	0.90%	0.49%	0.35%
Stand Dev	3.76%	5.10%	2.27%	0.29%
Skew	-0.84	1.01	0.60	1.78
Kurt	13.94	11.60	13.65	3.19
JB-Stat	12,935	9,100	12,312	1,504
P-value	(0.000)	(0.000)	(0.000)	(0.000)
n	1,575	1,575	1,575	1,575
Max	23%	49%	21%	2%
Min	-42%	-24%	-13%	0%

Long-term stock returns (arguably) exhibit mean reversion, there is a positive long-run equity risk premium, most assets exhibit leptokurtosis and the contemporaneous correlation between financial asset returns and real earnings growth is not strong.[15] We also find evidence that the real yield on T-bills exhibits strong persistence over time. The historical returns presented in Table 1 seem optimistic, but the future is unknown.

We define a hypothetical individual as follows: a 25-year old worker with a commencing salary of $40,000 and $0 in retirement savings, experiencing salary increases of 2 per cent per annum, contributing 9.5 per cent per annum of their salary to a retirement portfolio on a continual basis through each working year up to a retirement age of 65 years.

All analysis undertaken in this study is considered in real (inflation-adjusted) terms. On the matter of asset returns, we account for historical inflation in the block bootstrap (that is, the simulation approach generates many, many real return paths). By considering real returns, we can evaluate inflation-adjusted retirement income levels for retirees and the associated probability of ruin to age 90 (by asset allocation strategy).

A selection of the simulations (every 200th simulation from each round of 10,000) are presented in panels (a) to (d) of Figure 12 for each of the four strategies.

15 Studies have reported evidence of negative serial correlation, or mean reversion, over longer horizons (Fama and French, 1988; Poterba and Summers, 1988; Lo and MacKinlay, 1988). While attempts have been made to explain mean reversion (e.g. Malliaropulos and Priestley, 1999; Poterba and Summers, 1988; DeBondt and Thaler, 1987, 1989), no decisive argument has yet emerged. To complicate matters, a number of scholars find evidence against mean reversion (e.g. Richardson and Stock, 1989; Kim et al., 1991; McQueen, 1992; Miller et al., 1994).

FIGURE 12

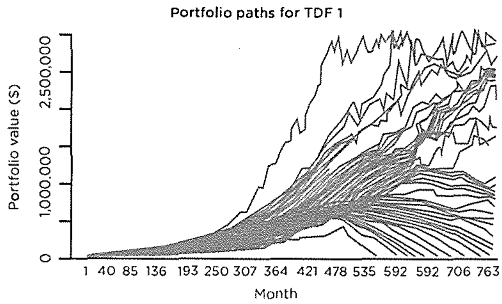


FIGURE 12A: Portfolio paths for the TDF 1 strategy (every 200th simulation path)

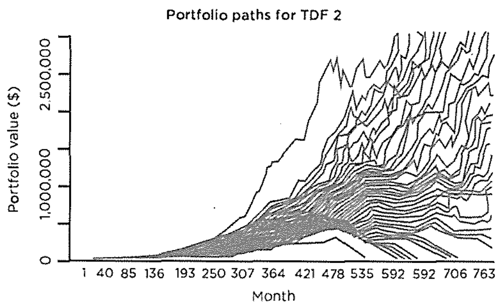


FIGURE 12B: Portfolio paths for the TDF 2 strategy (every 200th simulation path)

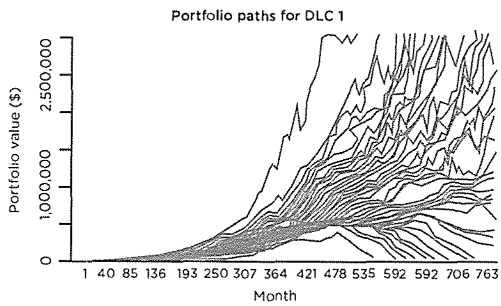


FIGURE 12C: Portfolio paths for the DLC 1 strategy (every 200th simulation path)

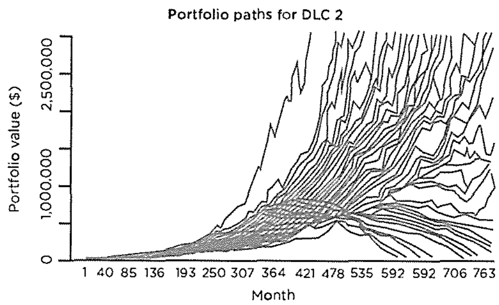


FIGURE 12D: Portfolio paths for the DLC 2 strategy (every 200th simulation path)

5. RESULTS

5.1 Wealth and income

We first show the cumulative distribution plots at various stages during the retirement phase for each of the four strategies. The sequence of panels in Figure 13 (panels (a) to (f)) progresses from five years prior to the retirement date to the terminal date of the individual (assuming death occurs at the age of 90 years). The horizontal axis of each panel represents the nominal dollar value of the portfolio while the vertical axis represents the probability of *failing* to achieve that level of wealth (for simplicity, we assume a $35,000 real income withdrawal level annually to age 90). In general, if the CDF plot for one strategy lies under (or to the right of) other CDF plots, then that strategy represents a superior outcome relative to the other strategies. The slope of each CDF function is an indicator of the variability of that strategy (the flatter the curve, the less variability of outcomes).

FIGURE 13

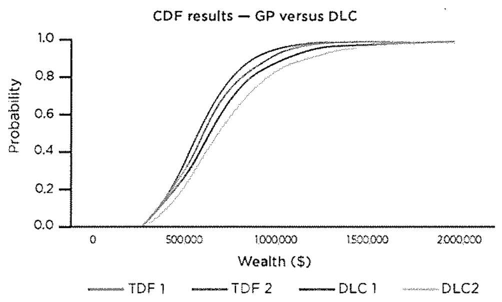


FIGURE 13A: Cumulative distribution of block bootstrap simulations for 2 TDF and 2 DLC strategies five years prior to retirement

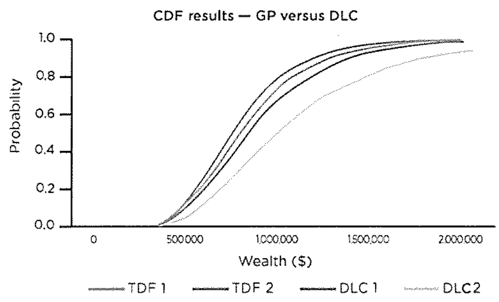


FIGURE 13B: Cumulative distribution of block bootstrap simulations for 2 TDF and 2 DLC strategies on retirement date

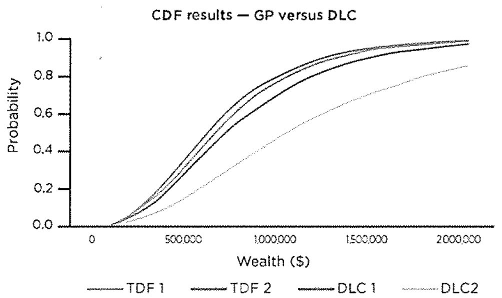


FIGURE 13C: Cumulative distribution of block bootstrap simulations for 2 TDF and 2 DLC strategies five years after retirement

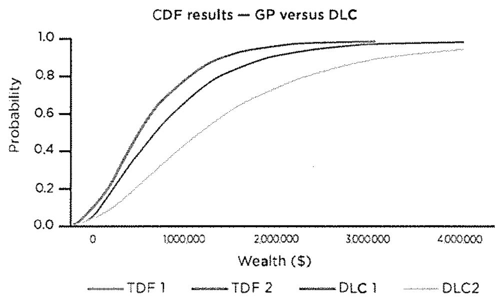


FIGURE 13D: Cumulative distribution of block bootstrap simulations for 2 TDF and 2 DLC strategies ten years after retirement (note the change in wealth values on x-axis)

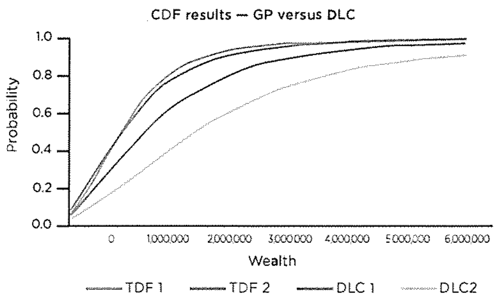


FIGURE 13E: Cumulative distribution of block bootstrap simulations for 2 TDF and 2 DLC strategies 10 years before death (note the change in wealth values on x-axis)

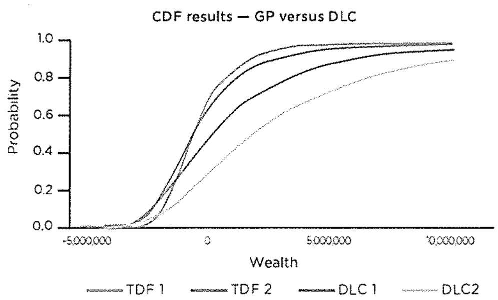


FIGURE 13F: Cumulative distribution of block bootstrap simulations for 2 TDF and 2 DLC strategies at death (note the change in wealth values on x-axis)

In each panel it is apparent that apart from a small portion to the left of zero wealth in the late retirement phase, the cumulative distribution plots of the DLC strategies outperform each of the TDF strategies. In particular, the DLC2 strategy, that takes advantage of a market value signal during the Retirement Risk Zone period, outperforms the DLC1 strategy that limits its dynamism to focussing on the target (i.e. it ignores current market valuations). The dynamic lifecycle strategy thus dominates the TDF strategies to the right of zero (i.e. in terms of positive wealth outcomes) but not to the left of zero (i.e. its worst outcomes are slightly worse than the worst TDF outcomes). While this violates the strict stochastic dominance criterion, it is only the very worst outcomes that do so. In such situations, an investor would be unhappy no matter what strategy they were invested in.

The median wealth outcomes and the normalised portfolio volatility for the four strategies during the Retirement Risk Zone are provided in two panels in Figure 14 (again, this assumes a $35,000 per annum real withdrawl rate to age 90). Volatility for the market aware DLC2 strategy increases with the other strategies during the withdrawal phase but at a decreasing rate. This illustrates that using market-aware investment strategies through the Retirement Risk Zone does not necessarily come at the cost of higher portfolio return volatility. In this way, we see tentative evidence that there may be a strategy that allows funds to assist superannuation investors to navigate the retirement risk zone.

FIGURE 14

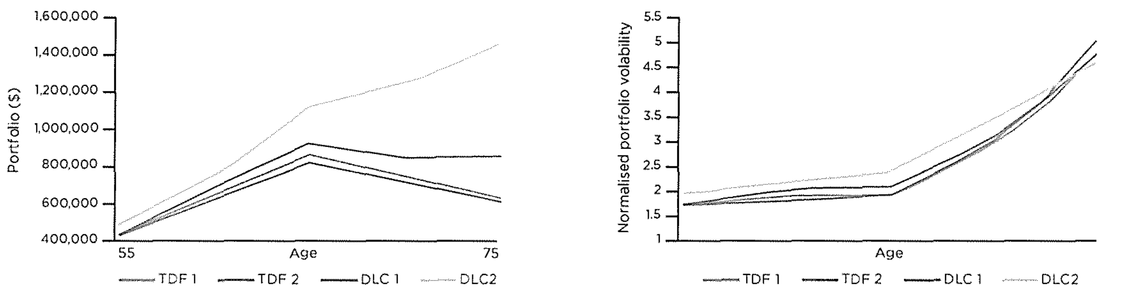


FIGURE 14A: Median wealth outcomes from portfolio path simulations for TDF1, TDF2, DLC1

FIGURE 14B: Normalised portfolio volatility from portfolio path simulations for TDF1, TDF2, DLC1

Let us now consider the relative performance of our four strategies from the perspective of risk (specifically, where risk is defined as portfolio ruin).

5.2 Median wealth outcomes, VaR and CVaR

The key risk measures (VaR and CVaR), as well as median wealth outcomes, for each of the four strategies are provided in Table 2.[16]

The results illustrate that the DLC approach tends to outperform (i.e. yields a higher absolute value) than TDF glide path approaches in terms of both risk metrics and median outcomes. Because of its dynamism, the DLC strategy attempts to preserve portfolio value during poor market conditions and takes advantage of better returns during positive economic conditions.

TABLE 2: Portfolio value five years prior to retirement, on the date of retirement, five years after retirement and 10 years after retirement for TDF1, TDF2, DLC1 and DLC2 strategies

	5% VaR	CVaR	Median
Retirement date -5 years			
TDF1	365,968	342,330	656,784
TDF2	355,646	322,515	611,961
DLC1	379,415	344,126	688,363
DLC2	388,581	353,071	743,032
Retirement date			
TDF1	511,783	464,635	890,188
TDF2	495,297	449,353	846,893
DLC1	520,544	476,519	942,770
DLC2	542,867	495,891	1,113,903
Retirement date +5 years			
TDF1	284,800	227,428	814,440
TDF2	278,963	205,102	796,086
DLC1	317,336	230,734	921,129
DLC2	385,497	267,415	1,287,984
Retirement date +10 years			
TDF1	16,272	-	710,854
TDF2	17,745	-	748,138
DLC1	66,571	45,860	931,343
DLC2	273,121	149,841	1,551,970

The retirement incomes that correspond to the wealth values shown in Table 2 are provided in Table 3. Both DLC strategies forecast higher annual retirement income for the 25 years of retirement at each confidence level. For the purposes of illustration, we had to select an annual retirement income level, based on the probability of portfolio ruin (as distinct from the arbitrary $35,000 real income withdrawal level per annum in the previous section). This annual income rate is a function of the asset allocation strategy selected. Specifically, the anchor chosen is the confidence level associated with the probability of ruin for each strategy, rather then comparing the same, fixed dollar amount across all strategies (this is due to each asset allocation strategy producing a different terminal wealth outcome). The confidence level is set at the point at which portfolio ruin can occur (a 10 per cent confidence level has been selected in Table 2 to correspond with a 10 per cent probability of portfolio ruin within 25 years assuming real income is maintained at this level throughout retirement). These values were derived using the stochastic optimisation technique discussed in Section 3.4. It is important to note that the confidence levels reported are computed at the retirement date. In reality, investors would be updating their preferences through time (say, annually) and assess their liabilities, retirement income withdrawal needs, market conditions and asset allocation accordingly.

16 The 5 per cent Value-at-Risk (VaR) is the value at which 95 per cent of all outcomes are superior and, therefore, 5 per cent of all outcomes are worse. One of the drawbacks of VaR as a risk measure is that it doesn't tell the analyst how bad the 5 per cent worst outcomes can be. Therefore, we supplement VaR with Conditional Value-at-Risk (CVaR), which is the average value of the 5 per cent worst outcomes. As such, CVaR must be less than (i.e. worse than) VaR.

TABLE 3: Sustainable annual retirement income withdrawals for 2, 10, 25 and 50 per cent confidence levels (probability of ruin) assuming constant annual withdrawals, for TDF1, TDF2, DLC1 and DLC2 strategies

	2% confidence	10% confidence	25% confidence	50% confidence
TDF1	$18,992	$26,128	$53,571	$60,804
TDF2	$22,364	$26,603	$64,817	$67,000
DLC1	$25,060	$37,894	$71,060	$90,017
DLC2	$28,310	$38,772	$98,909	$121,868

FIGURE 15: Sustainable annual retirement income withdrawals for 2, 10, 25 and 50 per cent confidence levels (probability of ruin) assuming constant annual withdrawals, for TDF1, TDF2, DLC1 and DLC2 strategies

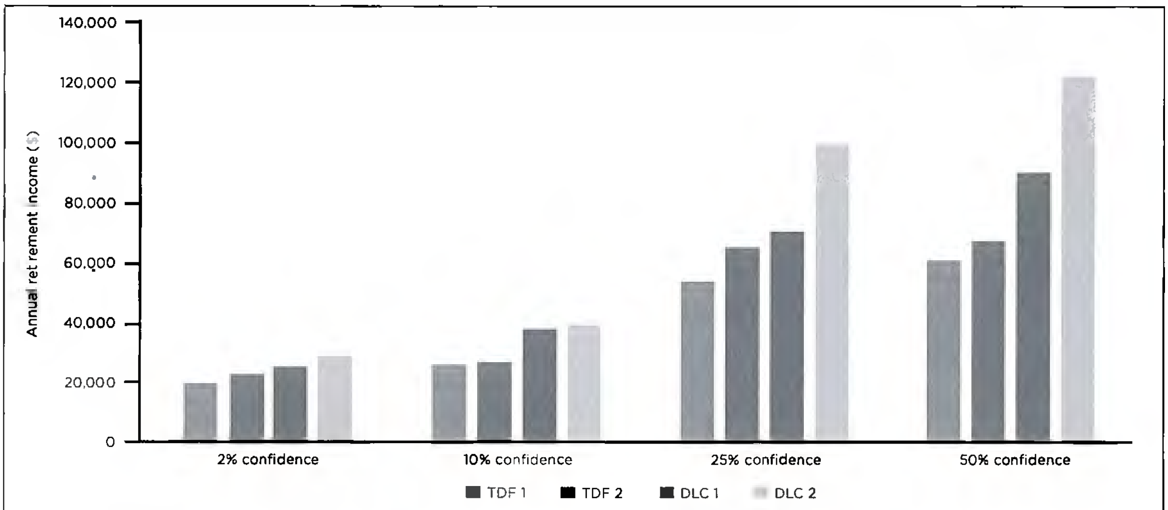


Figure 15 provides a pictorial representation of the income levels shown in Table 3. This analysis highlights some of the critical (and, at times, very complex) trade-offs facing retirees. This approach frames the problem of retirement income planning as one of understanding the investor's preferences regarding portfolio ruin. In short, the objective function for the investor is maximising through retirement (in this case, to age 90) income levels, subject to the risk of ruin. This is a very different decision frame to maximising wealth (popularly termed the 'pot-of-gold') at retirement. These trade-offs lie at the very heart of decision-making in account-based pensions.

5.3 Goals based investing

Goals-based investing is an investment approach that directly contrasts with conventional investing methodologies. A conventional investing methodology defines financial performance as a return against an investment benchmark or a peer group, with the major drawback being that performance can be considered 'good' regardless of whether the portfolio achieved positive or negative absolute returns. A goals-based approach instead focuses on funding personal financial goals rather than simply achieving higher investment returns relative to some arbitrary index or peer benchmark. Further, it proposes an investment approach for a household based on their risk capacity rather than their risk tolerance.[17]

Goals-based approaches is in essence are similar to asset-liability management (ALM) approaches adopted by insurance companies, and liability driven investment (LDI) approaches adopted by defined benefit pension funds. It is distinguished from these however in that it integrates financial planning (in simplified form) and investment management to ensure that household goals are financed.

17 Risk tolerance is an investor-specific attribute that describes how an investor copes with risk. Risk tolerance often varies with age, income and financial goals. Risk capacity refers to amount of risk an investor needs to take to achieve their financial goals. Many financial products target the investor's risk tolerance (e.g. a 'conservative' investment option) and remain largely ignorant of their financial goals. What we propose here is an approach that takes the amount of risk necessary to achieve the investor's retirement income goal.

For a goals-based investing approach to be most efficient, all household assets and liabilities across a lifetime need to be considered. Assets represent the full set of resources available to the investor such as financial assets, real estate, employment income and social security. Liabilities represent all financial obligations such as loans and mortgages, in addition to the capitalised value of the household's financial goals and aspirations. Goals such as educating children, retiring early and achieving a desired income level in retirement need to be articulated from the outset. The ultimate aim of this approach is therefore to prevent poor investment decisions by providing a clear process for identifying goals and choosing investment strategies for those goals. This approach not only adapts investment style to actual investors, it avoids the need to ensure that such investors have a superior understanding of financial markets and investment strategies. In this sense, such an approach is ideal for a product-based offering.

5.4 Incorporating the age pension

Fiscal constraints, and demographic headwinds, mean that states will struggle to fully support an ageing population of retirees for 20 to 40 years' worth of pension payments. Goals-based investing has emerged to address retirement needs, not only as a form of financial security at the individual level (a 'micro' question), but also as a form of prudent social policy (a 'macro' or public policy question). If investors are achieving better outcomes on an individual basis due to improved investment strategy it might be possible to relieve the pressure on the social security system. Whatever improvements in investment strategies that might result from this or any other research, we concede that a significant number of individuals will continue to rely on the age pension to supplement their retirement income.

To ensure the model is robust and general, the age pension is implicitly incorporated into the model via the SSP variable in Equation 3, and can be introduced via decision rules related to asset and income means testing. Given the current debate regarding the future of the age pension in Australia, we leave this as an important area for future research.

5.5 Lump sum withdrawals at or after the date of retirement

The model also allows for lump sum withdrawals on the date of retirement which provides greater flexibility for investors to gauge the implications for retirement income of extinguishing mortgages and other loans. The anticipated lump sum is necessary to compute expected retirement income because it will obviously have an effect on portfolio sustainability.

Unplanned lump sum withdrawals are, however, more complex to model, and will have a significant effect on the sustainability of the portfolio, especially when they occur early in retirement. For instance, large unexpected age-related health costs (hearing aids, elective surgery, chronic disease treatments, etc.) and/or aged-care costs may significantly impact the longevity risk of retirees. A successful but costly treatment may have the paradoxical effects of extending life expectancy and reducing portfolio sustainability. There is the danger that improved health can lead to poverty. These possibilities are not included in this model, but have been addressed in other recent research (for instance, see Drew, Walk and West, 2014, working paper).

6. ASSET ALLOCATION THROUGH THE LIFE COURSE: THE NEXT STEPS

This study is concerned with asset allocation decisions over the life course (hopefully, the very long run for all!). We considered a timeframe of some 65 years (from 25 thorough 90 years of age). Imagine all of the changes in the world that a 25 year old in the early 1950s would have witnessed through to being 90 years of age today. Moreover, consider the myriad of economic, financial and geopolitical events that affected markets during this period, not to mention the many personal and household events (family, health, career, etc.) that also would have impacted on asset allocation and financial decision making.

In short, perhaps sadly, all we really do know about asset allocation and navigating both to and through the Retirement Risk Zone is that uncertainties are pervasive and outcomes are not assured.

All we really do know about asset allocation and navigating both to and through the retirement risk zone is that uncertainties are pervasive and outcomes are not assured.

In a superannuation or DC plan system like Australia, this perhaps leave us with the question of how we can nudge the balance of probabilities in favour of investors, to give them the 'best' chance of securing a sustainable retirement income.

We highlight the following areas where investors could do with some help:

Outcome awareness

Outcome- (or goal-) oriented investing takes its cues from liability driven investing (LDI) models. The goal of a LDI investment approach is to design as asset portfolio to meet both current and future liabilities. This requires a laser-like focus on the outcome (say, the investor's liability of a sustainable retirement income stream). This can be challenging in a superannuation/DC framework where we largely focus success on a pot-of-gold at retirement, not a retirement income stream through retirement. Considering lessons from behavioural finance, how do make retirement outcomes meaningful to people through various life stages?

Prescription versus dynamism

The merits of prescriptive (or off-the-shelf) glide path designs continue to be challenged. Outcome-oriented approaches to investing — such as those explored in this report with retirement income the objective function — require greater flexibility. While the surface level simplicity of simple glide path designs is appealing, we need only look to the recent past (e.g. the performance of the 2010 TDF cohort during the global financial crises in the US) to see the limitations of such an approach.[18] If we agree that markets are dynamic, why do our approaches to asset allocation not similarly reflect this dynamism?

Market awareness

This report has used a simple, replicable approach to form a view on relative value (which also implicitly assumes a belief in mean reversion in stock returns). Issues of mean reversion and whether or not information from the past can garner insights about the future is not a trivial debate in both practitioner and academic circles (for instance, see the debates arising between Nobel Prize winners Professors Eugene Fama and Robert Shiller).[19] In practice, there is both academic and practitioner research that supports that idea that having a sophisticated dynamic asset allocation (DAA) approach, with a focus on five- to seven-year timeframes, may be able to assist in smoothing volatility. Discipline of process when markets deviate from 'fair value', and implementation, are important considerations in the debate. However, as this report (and others) has shown, the potential merits of a market aware approach seem to suggest that it is a path worthy of further consideration by sophisticated investors.[20] While the debate regarding the efficient market hypothesis (EMH) is one that, at times, tends to generate far more heat than light, policy issues of mean reversion and its impacts on asset allocation are topics that investment committees must have a clear and defensible position.

18 Brien MJ, Cross PJ and Constantijn WA (2009), 'Target Date Funds: Historical Volatility/Return Profiles', Deloitte Financial Advisory Services LLP.

19 Allen K (2013) 'Nobel prize-winning economists take disagreement to whole new level', The Guardian, 11 December.

20 For an academic perspective, see Shiller (2000); Campbell and Shiller (2001); Kritzman, Page and Turkington (2012); Asness, Clifford, Moskowitz and Pedersen (2013).

Black swans

Perhaps it goes without saying, but in many superannuation (DC) asset allocations, the timing of black swan events is critical. We know that the holding of growth assets (such as equities) in portfolios tend to dominate risk budgets. This is even more acute when the largest amount of retirement savings is at risk (cf. portfolio size effect of Basu and Drew, 2009). This report attempts to provide insights into asset allocation over the life course; however an area for further research is the price of tail hedging and the opportunity cost of such an approach.[21] The question we ask here is that investors seem happy to insure against a myriad of risks across the life course (life, trauma, home and contents and car), why would we not give similar consideration to issues of, say, sequencing risk in DC plans?

Complexity

One of the challenges to more dynamic approaches to the problem of retirement investing is complexity. As we have alluded to on numerous occasions throughout the report the Retirement Risk Zone (by its very nature) is characterised by complexity. There are a myriad of *endogenous* (human capital, health, household, family) risks and *exogenous* (labour market, economic and financial shocks, geopolitical events) risks that are borne by individuals in DC systems. We would suggest that there is an important policy discussion to be had that begins by acknowledging just how complex DC plans are and how we can nudge households into better decisions. An interesting study by Milevsky (2008) showed that listed firms that freeze their DB plan enjoy a positive announcement effect of 3.8 per cent. In a retirement system with little pooling, how well have we really prepared households (and their respective balance sheets) in Australia to manage the complexities of superannuation?

'Both-and' versus 'either-or'

We have reiterated many times that this report focuses on asset allocation and its role of navigating people both to and through the Retirement Risk Zone. We need to state categorically that our motivation was to provide positive insights into asset allocation through the life course. With this baseline established, we can now have 'both-and' conversations on the role of annuities and deferred annuities, longevity swaps and other important building blocks in the solving the puzzle of retirement income.

We absolutely reject 'either-or' framing in this debate. For various reasons (the complexity of the problem, commercial interests, political expediency, professional pride), there has been too much time spent on looking for silver-bullet solutions that simply do not, in our view, exist. How holistic is our approach to retirement income solutions? Is our philosophy truly 'both-and' when it comes to the challenges of retirement income planning, or really, in practice, 'either-or'?

Fees

The decision to take a more dynamic approach is not a cost free decision. Somewhat unfortunately at times, the fee debate in Australia (and globally) seems largely framed around management expense ratios for active managers. Again, we wish to be clear, we believe too many folks seek an additional one per cent return, rather than controlling things like fee levels. However, the fee debate is something more than simply investment manager remuneration. It is our conjecture that we need to frame fees as the cost of pursuing an outcome (in this case, a sustainable retirement income). When framed this way, an outcome-oriented way, we can then think (and act) more holistically regarding fee budgeting.

21 See, for example, Basu and Drew (2014).

Governance budget

It is our conjecture that the complexity facing investors across the life course is not going away quickly. In fact, the more we save for retirement, the larger the portfolio size effect and the amplification of sequencing risk. As an industry, there seems to be much energy spent on publishing management expense ratios. Why would we not publicly disclose governance budgets?

Governance is not free, and good governance is priceless. The nature of the task is such that funds require best practice fiduciary (trustee) governance, the necessary C-suite leadership and support, and organisations capable of delivering high quality retirement solutions. Perhaps focussing more closely on the key enabling capability of investment governance will encourage funds to continue to invest in raising standards.

A lack of financial security is a key contributor to an anxious retirement. International evidence, particularly from the US, is that many recent, or soon-to-be, retirees have expressed dissatisfaction with the existing approaches to asset allocation over the life course, especially using relatively simple TDF glide paths. This report has shown how approaches that take a more dynamic, market-aware approach to the problem of asset allocation over the life course may improve the balance of probabilities in the favour of the investor. Our findings suggest that there are a range of layers (target tracking, transition, and market valuation) that may be incorporated into the asset allocation decision that can potentially be accretive to retirement outcomes. Our search to find 'safe passage' both to and through the retirement risk zone continues.

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