THE TWO FACES *of investment performance and risk*

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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

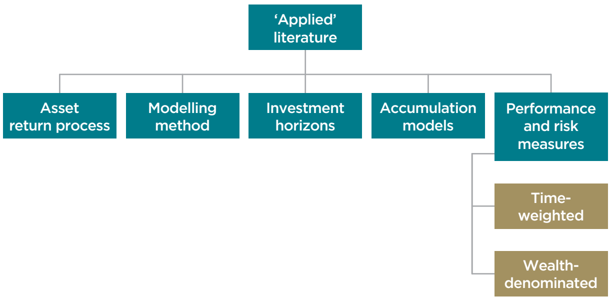
The data used in this study are the well-known, and commonly used, monthly stock and Treasury bill (T-bills) returns maintained by French (2012).[1] We justify our focus on stocks with the logic that, irrespective of the actual asset allocations of a typical long horizon investor, portfolios with a material 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

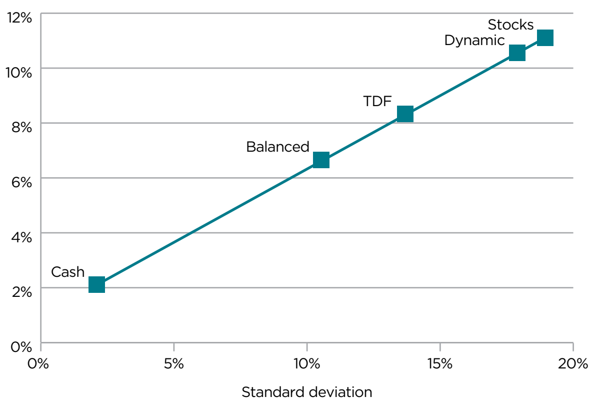
This table presents four time-weighted measures of performance and risk calculated using the stationary bootstrap method for a 40-year investment horizon. Estimates for mean and standard deviation (St. Dev.) are expressed in percentage terms, and estimated Sharpe ratios (as the name suggests) are ratios.

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.

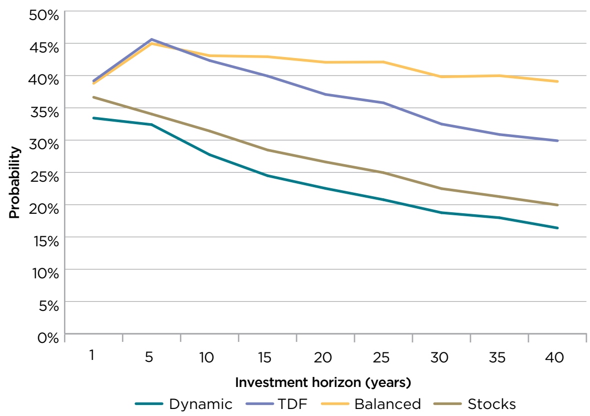
Strategy	Median RWR	P (shortfall)	E (shortfall)	Sortino
Stocks	20.41	20%	0.67	9.97
Balanced	11.35	39%	1.06	1.35
TDF	13.73	30%	0.82	3.35
Dynamic	17.94	16%	0.56	7.95
Cash	4.21	100%	5.48	-0.98

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

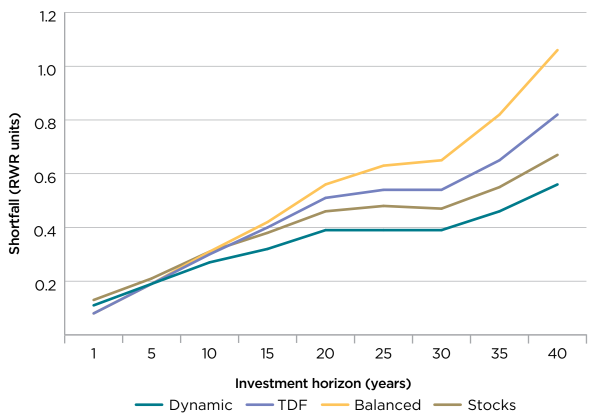
Using the stationary bootstrap simulation method, we report three target-relative measures. Panel A presents the probability of a shortfall expressed in percentage terms, Panel B shows the expected shortfall in RWRT terms, and Panel C presents the Sortino ratio as a ratio of above-target reward to below-target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

PANEL A: Probability of a shortfall



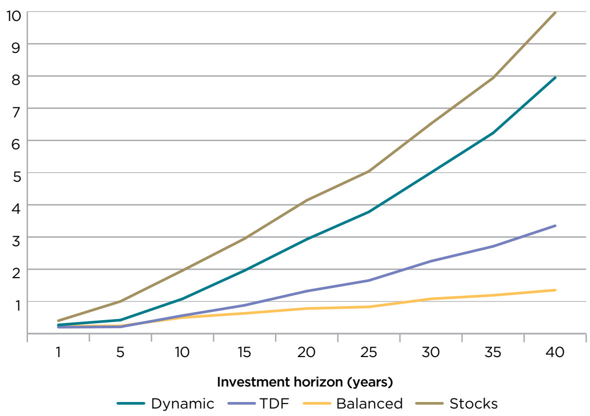
Two themes emerge from a review of the probability of shortfall estimates shown in Panel A of Figure 3. First, we see a relationship between the allocation to risk assets and the absolute level of shortfall probability. Generally speaking, the higher the allocation to risk assets the lower is the absolute 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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