Decentralised portfolio management: analysis of Australian accumulation funds.

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Abstract

In Australia, pension fund trustees choose investment managers on behalf of members. We investigate the structure and performance of delegated investment choice in the Australian retirement incomes sector. We find that funds where trustees employ many managers generate higher risk-adjusted returns over the 3 year sample than those with few, but funds with 13 or fewer managers show no improvement over funds with a single diversified manager. All do worse than a benchmark portfolio of asset class indices. Random selection mimics the choices of an uninformed individual selecting from a 401K plan or retail superannuation fund menu. Returns from funds with large numbers of mandates compare favourably with returns from randomly selected equally weighted portfolios, but this improvement falls off quickly for funds with fewer mandates, or when naive portfolios are diversified across asset classes. Results indicate that an uninformed individual following a naive diversification strategy does as well as most funds in this sample.
1 Introduction

This paper reports on the structure and pattern of delegated or decentralised investment choice in the Australian retirement incomes sector and weighs it up against standards of efficiency established by portfolio theory. Using a new and unique dataset on almost two hundred not-for-profit superannuation (pension) funds and their investment delegation patterns, we measure the relative performance of funds which use many investment managers (known as ‘mandates’) against the performance of similar funds which use fewer managers, and against naive portfolio strategies. We find that while superannuation funds which employ a very large number of investment managers generate higher risk-adjusted returns over the sample than other superannuation funds, results for funds with 13 or fewer mandates (managers) show no improvement over, and may do worse than funds employing a single diversified manager. Returns from funds with large numbers of mandates compare favourably with returns from randomly selected naive portfolios, but this improvement falls off quickly for funds with fewer mandates, or when naive portfolios are diversified across asset classes. We find that trustees do no better than an uninformed individual who randomly chooses one manager for each major asset class, then builds an equally-weighted portfolio.

In comparing the Australian arrangements with international experience we see that for Australian not-for-profit superannuation funds, the choice of specific investment managers is delegated to trustees and their consultants. Individual members of superannuation funds allocate assets to individual investment funds indirectly through their choice of multi-manager diversified and specialist asset allocation options. This practice raises questions as to the efficiency of direct, as opposed to delegated (or decentralised), choice of investment funds, a question of increasing urgency and relevance in many pension systems.

Retirement income systems around the world are evolving from defined benefit arrangements towards privately managed accumulation plans. Increasingly, under these ‘new’ arrangements, plan participants must make decisions about how their assets will be allocated across a menu of investment choices. Current practice in relation to the responsibility for the menu,

\footnote{We thank Alex Dunnin and others at Rainmaker Information for generous help with data and advice. We gratefully acknowledge the support of the Australian Research Council.}
and composition of the menu, differs widely between countries.

Under the voluntary company-sponsored 401K plans prevalent in the United States, plan participants are generally offered choice among a range of specific investment funds. Plan sponsors (employers) and/or plan administrators decide which investment funds will be included on the menu and plan participants then allocate their assets across the investment funds offered. Recent surveys of 401K plans suggest that the median number of investment choices was around 10-12 and that the investment funds generally covered the standard range of asset classes (Elton, Gruber and Blake 2004, Mitchell, Utkus and Yang 2005). As well, recent proposals for the reform of US Social Security include personal retirement accounts offering limited choice of investment options (Cogan and Mitchell 2003).

Since 2000, public pension participants in Sweden have been required to place 2.5 percentage points of their mandatory Premium Pension contributions into individual accounts. The arrangements are organised on a national basis, with a government agency (the PPM) setup to administer the plan and act as a clearinghouse. Any investment fund company licensed to do business in Sweden is allowed to participate in the system, and the menu of investment funds has grown from 460 at commencement in 2000, to over 650 by 2004. Most are specialised funds and plan participants must choose among these to put together a portfolio of up to 5 investment funds (Sunden 2004, Palme, Sunden and Sonderlind 2005). Despite the availability of a default fund, over 70 per cent of participants have made ‘active’ choices.

In Australia, both mandatory and voluntary superannuation (pension) plans coexist. The superannuation guarantee requires employers to contribute at least 9 per cent of an employee’s income into a superannuation (pension) fund. Previously choice of superannuation (pension) fund lay with employers, but from July 2005 choice of superannuation (pension) fund is

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1The adequacy and characteristics of the direct choice of investment funds offered to 401k plan participants is analysed by Elton, Gruber and Blake (2004). They find that for 62 per cent of plans, the menu of investment funds offered are inadequate, which over a 20 year period would make a difference in terminal wealth of over 300 per cent. As well, they find that the investment funds included in the 401k plans are riskier than the general population of funds in the same categories, but that the funds included in the plans outperform a menu of randomly selected funds.

2The US President’s 2005 State of the Union address emphasised the need for social security reform and the benefits of individual accounts with participant-directed investments.
available to employees. Irrespective of who chooses the superannuation fund, participant investment choice within a given superannuation fund is both prevalent and increasing.

The Australian superannuation industry is characterised by considerable diversity of design, and the extent and composition of investment choice differs commensurably. In general, not-for-profit superannuation funds offer, as a minimum, choice across multi-manager diversified portfolios (typically classified by the standard options of ‘capital guaranteed’, ‘capital stable’, ‘balanced’, ‘growth’, etc.) while retail superannuation funds offer choice across single manager specialised investment funds. Compared with 401K plans (and Australian retail funds), not-for-profit superannuation funds typically use an additional layer of investment management, where trustee boards choose specialised investment managers on behalf of individual members. We can use this variety in choice and management structures in the Australian superannuation system to evaluate alternative arrangements.

We begin with a review of the literature on decentralised portfolio management (Section 2), followed by a description of the current practices in investment delegation by not-for-profit superannuation funds (Section 3). Section 4 describes the database of superannuation fund investment portfolios and Section 5 outlines the empirical tests and results. Section 6 concludes.

2 Decentralised management in portfolio theory

If payoff patterns of individual assets were independent, then investors could completely eliminate portfolio risk by adding one asset to another, driving average portfolio volatility down to zero in the limit. But payoffs tend to covary and this common movement cannot be completely diversified away. In order to achieve least risk at the portfolio level, a central manager must look at the return and volatility structure of the entire portfolio of securities, since isolating one group of securities from another can leave out crucial covariance information and generate sub-optimal outcomes.

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3There are, of course, many exceptions to these broad statements. For example, in 2004, the not-for-profit industry superannuation fund REST offered choice across both multi manager diversified options and multi manager by asset class; the not-for-profit industry fund Sunsuper offered choice across single and multi manager diversified and specialised; and the retail superannuation fund AMP Flexible Lifetime Super offered choice across single and multi manager diversified and specialised (Bateman and Hill 2004).
We achieve least portfolio risk when asset allocation decisions are based on the most accurate forecast of covariances. Using an incomplete or inefficient second moment forecast increases portfolio risk. Where a central manager combines the funds of two or more decentralised managers, each of whom forms an optimal portfolio for only a subset of assets, there is a danger that covariance information will be overlooked, introducing inefficiency. Consider the allocation problem of a mean-variance investor with a single horizon. The investor chooses portfolio weights as the solution to the problem:

\[
\min \frac{1}{2} \mathbf{w}' \Sigma \mathbf{w}
\]

subject to:

\[
\mathbf{w}' \mathbb{E}(\mathbf{r}) + (1 - \mathbf{w}' \mathbf{1}_N) \mathbf{r}_f = \mathbb{E}(\mathbf{r}^p)
\]

where \(\Sigma\) is the \(N \times N\) covariance matrix of the risky securities, \(\mathbf{r}\) is the \(N \times 1\) vector of risky security returns, \(\mathbf{r}_f\) is the return to the risk-free asset, \(\mathbf{1}_N\) is an \(N \times 1\) vector of ones, and \(\mathbf{w}\) is an \(N \times 1\) vector of portfolio weights in the risky securities. Efficient portfolios are linear combinations of risk-free asset holdings and a portfolio of risky assets (tangency portfolio):

\[
\mathbf{w}_C = \frac{1}{\mathbf{1}_N' \Sigma^{-1} \mathbb{E} (\mathbf{r} - \mathbf{r}_f)} \Sigma^{-1} \mathbb{E} (\mathbf{r} - \mathbf{r}_f),
\]

where \(\mathbf{r} - \mathbf{r}_f\) is an \(N \times 1\) vector of excess returns to the risky assets relative to the risk-free asset \(\mathbf{r}_f\). (We drop the expectations operator for convenience at this point.) Tangency portfolio weights depend on the full covariance matrix, \(\Sigma\).

Now suppose that the central investment manager wishes delegate portfolio allocation to two asset class specialists. Divide the set of risky securities into two sub-classes, of length \(N_1\) and \(N_2\), \((N_1 + N_2 = N)\) and assume that each specialist optimises her portfolio within her separate class without regard to the other. Asset manager \(j, j = 1, 2\) will hold a tangency portfolio within her sub-class given by:

\[
\mathbf{w}_i = \frac{1}{\mathbf{1}' \Sigma_{jj}^{-1} (\mathbf{r}_j - \mathbf{r}_f) \Sigma_{jj}^{-1} (\mathbf{r}_j - \mathbf{r}_f)} \Sigma_{jj}^{-1} (\mathbf{r}_j - \mathbf{r}_f).
\]

If the central manager attempts to combine these two portfolios, essential
information about the covariance between sets 1 and 2 is missing. The partitioned covariance matrix for the decentralized problem $\Sigma_D$ is block diagonal:

$$
\Sigma_D^{-1} = \begin{pmatrix}
\Sigma^{-1}_{11} & 0 \\
0 & \Sigma^{-1}_{22}
\end{pmatrix}.
$$

(5)

The best possible combination of the two sub-portfolios, assuming that the true complete covariance relationship is not known to the central manager, will be:

$$
w_D = \frac{1}{\text{Tr} \Sigma_D^{-1}(r - r_f)} \begin{pmatrix}
\Sigma^{-1}_{11}(r_1 - r_f) \\
\Sigma^{-1}_{22}(r_2 - r_f)
\end{pmatrix}.
$$

(6)

The weights from (6), $w_D$, will not be equal to the centralised optimum, $w_C$, in general. To see the inequality, decompose the partitioned inverse of $\Sigma_C$ such that

$$
\Sigma_C = \begin{pmatrix}
\Sigma_{11} & \Sigma_{12} \\
\Sigma_{21} & \Sigma_{22}
\end{pmatrix}
$$

(7)

$$
\Sigma_C^{-1} = \begin{pmatrix}
\Sigma^{-1}_{11} (I + \Sigma_{12} \Sigma_{21} \Sigma^{-1}_{11}) - \Sigma^{-1}_{11} \Sigma_{12} F_2 \\
- F_2 \Sigma_{21} \Sigma^{-1}_{11} F_2
\end{pmatrix}
$$

(8)

$$
F_2 = (\Sigma_{22} - \Sigma_{12} \Sigma^{-1}_{11} \Sigma_{21})^{-1}
$$

Portfolio weights for the optimal centralised portfolio are:

$$
w_C = \frac{1}{\text{Tr} \Sigma_C^{-1}(r - r_f)} \Sigma_C^{-1}(r - r_f)
$$

$$
= \frac{1}{\text{Tr} \Sigma_C^{-1}(r - r_f)} \begin{pmatrix}
\Sigma_{11} (I + \Sigma_{12} F_2 \Sigma_{21} \Sigma_{11}^{-1})(r_1 - r_f) - \Sigma^{-1}_{11} \Sigma_{12} F_2 (r_2 - r_f) \\
F_2 (r_2 - r_f) - F_2 \Sigma_{21} \Sigma_{11}^{-1} (r_1 - r_f)
\end{pmatrix},
$$

(9)

which equals $w_D$ where $\Sigma_{12}$ and $\Sigma_{21} = 0$, and therefore is sub-optimal in every other case but one. The exception applies when the vector of expected returns is an eigenvector of the matrix $\Sigma_C \Sigma_D^{-1}$, such that $\Sigma_C \Sigma_D^{-1} (r - r_f) = \lambda (r - r_f)$. In that case the decentralisation process produces a costless mistake, and portfolio weights are equal from both optimisations, such that $w_C = w_D$.\(^4\) In the case of a portfolio with two risky assets, for example,\(^4\)

\(^4\)For proof of this proposition in a more general context see Engle and Colacito (2004).
such a costless mistake arises when the Sharpe ratios of the two risky asset are equal. In virtually all cases, combining separately optimised asset classes while ignoring cross-correlation relationships as in (6) above will be suboptimal.\footnote{Realised portfolio standard deviation will be higher in every case of a portfolio that is constructed over a covariance matrix that deviates from the true one, and that the resulting increase in portfolio risk relative to the true covariance is an indicator of inefficiency (Engle and Colacito 2004).}

This simplified example draws out the potential problems of two-stage optimisation, but omits the real reason that specialist managers might be preferred to the centralised choice. In the CAPM world of Sharpe (1964) or the ICAPM of Solnik (1974), all investors hold some combination of the market portfolio (appropriately defined) and the risk-free asset. No conflict can arise between the ultimate beneficiary of the investment (who generates utility by consuming) and the delegated manager, since only two portfolios matter: the risk-free asset and the market portfolio. Investors universally observe the market portfolio’s risk and return characteristics and so achieve maximum efficiency by combining the two portfolios according to the risk tolerance of the agent. But if investors are unsure about the moments of returns distributions, or if all information is not fully disclosed, or other market inefficiencies exist, then we might be able to ‘improve’ on the market portfolio.

The fact that people in charge of large pools of money hire managers is evidence, according to Sharpe (1981, p 218) that ‘they do not believe that the market is perfectly efficient. They hire investment managers in the belief that the managers they select can make better predictions in at least some domains than can the average, or ‘consensus’ investor’. Sharpe also observes that specialist managers are often given myopic investment objectives, meaning that they are not expected to coordinate selections with the other managers, hence potentially ignoring valuable information in security covariances. He goes on to identify the circumstances where the better predictions of specialist managers can compensate for efficiency losses arising from the delegation process.

Sharpe defines the decentralised portfolio selection process as an extra level of diversification. He distinguishes diversification of judgment where a central manager selects more than one delegated manager to mitigate serious prediction errors, but where delegated managers can choose from all
available securities, and *diversification of styles*, where delegated managers analyse a discrete subset of securities. The potential for selecting efficient centralised portfolios varies with these different types of diversification.\(^6\)

In the case of a central manager diversifying by judgement, efficient myopic decisions rules are possible if there is consensus about covariance predictions and the elements of the set of returns predictions from any delegated manager are equally accurate. If such uniformity of prediction error holds, the central manager diversifies across judgements by combining delegated manager portfolios according to her assessment of each delegate’s accuracy. The resulting combined portfolio is efficient under myopic rules: each active manager simply chooses a minimum variance portfolio subject to their own predictions, the passive manager chooses a minimum variance portfolio subject to the consensus predictions and the central manager creates a weighted average of all delegated portfolios depending on evaluations of each active manager’s accuracy. To make this work, the central manager does not need to know active predictions of individual portfolio returns.

If the problem is restricted to the case where managers optimise only over a subset of securities (i.e., diversification of style) myopic decision rules are usually not optimal, even where there is consensus about the covariance matrix. The first-best outcome cannot be attained in one step, and Sharpe proposes a two step process, where one active manager myopically optimises over her subset, and the second active manager is compelled to consider the return and variance of her own portfolio along with its covariance with the remaining portfolio (that part due to manager one.) However this two-step process may be simplified if security returns are well described by a factor model.

Treynor and Black (1973) first derived a factor model of delegated management, more recently revised and extended by Elton and Gruber (2004). In this case, the centralised decision maker is a mean-variance optimiser who believes that security returns are generated by a set of indexes, which can be held as passive portfolios. The investor can build an optimal aggregate portfolio if active managers are required to hold securities in proportion to their alpha to non-systemic risk ratio. As long as active managers will tell the central manager their estimate of alpha for the whole active portfolio, \(^7\)

\(^6\)Sharpe restricts analysis to the case where managers disagree about expected returns but hold a consensus estimate of covariances.
the residual risk of the active portfolio, and the sensitivities (betas) of the active portfolio relative to the indexes, the central manager can construct an efficient portfolio as a weighted combination of optimal active and passive portfolios.

Importantly, the central manager in this case can combine overlapping and/or bounded active portfolios without being told specific security forecasts and without consensus on covariance structure. This is possible because of the key feature of the system: an index-based returns process summarising covariance information for all investors in terms of two passive indexes.

Despite (or perhaps because of) gaps in information transmission between central and delegated managers, there are clear trends in the Australian retirement savings system towards decentralised investment. We aim to unpack the system of delegation by which retirement savings in Australia are invested, and secondly, to evaluate the effectiveness of delegation by a series of performance and efficiency measures. Section 3 sketches the features of investment delegation among not-for-profit superannuation funds and sets out recent trends and projections.

3 Decentralised management in not-for-profit superannuation funds

The investment decision of members of not-for-profit superannuation funds pass through two layers of delegation. At one level, members can choose to allocate their assets/contributions across a number of multi-manager diversified portfolios, (although there is increasing choice offered of ‘multi manager by asset class’, ‘single manager diversified’ and/or ‘single manager by asset class’). But at the next level, decisions about the investment managers (mandates) operationalizing these choices are made by trustees and their consultants.

Trustees co-ordinate the choices offered to members and the underlying investment mandates. While the duties of trustees include administration, regulatory compliance and communication with members, their foremost task is efficient investment. Legislation specifically requires trustees to implement an investment strategy that ‘has regard to... the composition of the fund’s investments as a whole including the extent to which the investments
are or are not diversified and the associated risks.’ (APRA 1999, II.D.1).
Hence trustees are expected to co-ordinate and centralise superannuation investment.

(From now on we use the term ‘trustee’ to denote the central investment manager of a retirement savings fund, and ‘manager’ to denote a contracted investment agent of the trustee.)

Delegated management is increasing and becoming more specialised (Rainmaker 2004). Whereas diversified mandates instruct the manager to invest across a range of asset classes, specialised mandates restrict the manager to a designated area of expertise, usually an asset class, subclass and or ‘style’. The responsibility to monitor and manage risk, and diversify effectively, remains with trustees even when parts of the investment portfolio are managed under a contract (mandate), and investment mandates are themselves regulated, and must include explicit investment constraints, performance or benchmark standards, reporting and auditing standards, fee and charges schedules as well as dispute resolution procedures and termination conditions. However mandates are confidential documents and a superannuation fund’s underlying investment strategies and fee structures at the level of individual mandates are not disclosed to members. Most fund members must rely on trustees’ reports, for investment and fee information.

3.1 Industry structure

[INSERT FIGURE 1 HERE]

The Superannuation Guarantee system in Australia is built on individual accounts held in publicly- or privately-managed superannuation funds. Figure 1 shows examples of choices offered to new members of not-for profit funds: capital stable, balanced or growth (reflecting increasing exposure to riskier asset classes). Many superannuation funds also allow individuals to chose their own combination of specific asset classes, rather than a ‘pre-mixed’ option. Prospectuses for new members commonly display charts or tables showing the benchmark asset class weightings underlying each type of account alongside descriptions of account options. Balanced options, which typically cover domestic and international fixed interest, equities and cash, are the most popular choice, and also the most common default (in the event that a new member makes no active selection). When members select an investment option, they are instructing trustees on how their personal ac-
counts should be invested. Once contributions are in the hands of trustees, however, any clear delineation between account options is submerged into the mandates comprising the superannuation fund’s investment pool.\(^7\)

In most cases trustees will engage an asset consultant to advise on the choice of managers, investment strategies and allocations. Sometimes, under implemented consulting arrangements, the asset consultant also engages the managers for the superannuation fund. Having formulated a strategy, trustees then issue contracts or mandates to managers, setting out specific instructions, performance standards and fees, as noted above. This portfolio of investments under mandates, generate returns that are eventually passed back to members as crediting rates after taxes, fees, expenses, and smoothing are deducted.

### 3.2 Recent trends

Rainmaker (2004) surveys the delegated investment (mandate) ‘pipeline’ for 269 not-for-profit superannuation funds, encompassing $204 billion funds under management (FUM) and including government, industry and corporate funds. There are some clear trends:

- by far the majority of FUM are invested via delegated managers (93 per cent of the total FUM in the survey);
- the average number of mandates per manager is 22 and the average mandate size is $65 million;
- the average number of mandates per superannuation fund is 12, twice as many as in 1998, but some funds issue many more mandates (over 50);
- large funds issue more mandates than small funds at a ratio of about four to one, and funds employing asset consultants issue about twice as many mandates as those which do not;
- more than half of the mandate holders surveyed are foreign owned and these foreign providers manage more than half the FUM in the survey;

\(^7\)By contrast, retail superannuation funds allow choice directly from a menu of investment managers – both diversified and by asset class (rather than constructed options) and consequently more closely resemble 401K plans.
- diversified mandates (covering a range of asset classes and styles) are becoming less popular and are increasingly associated with defined benefit superannuation funds. In 1998, Rainmaker report that 50 per cent of mandates were diversified, whereas the current figure is 15 per cent, indicating strong trends towards specialised mandates; and

- mandates are usually specified over a three to four year contract period, suggesting that about 21 per cent of FUM ‘turns over’ each year as mandates are renegotiated.

Asset consultants play a crucial role in the delegated management process, and the consulting industry is becoming more concentrated. While there are 22 asset consultants advising Australian superannuation funds, the ten largest consulting firms control 97 per cent of the funds under asset consultant advice. In addition, the number of asset consultants has almost halved in the past five years as consultants themselves specialise in the types of superannuation funds they advise.

We aim to investigate investment choice by evaluating the performance of a large sample of superannuation funds representing the spectrum of mandate patterns. We conduct tests and simulations which allow us to gauge the value of more or less mandates firstly within the group of not-for-profit funds themselves and secondly against a benchmark portfolio constructed from asset class indices.

4 Data

Rainmaker Information collects data on mandate patterns for 269 not-for-profit superannuation funds, representing around 90 per cent of the not-for-profit share of the superannuation sector. Of these 269 funds, we selected 198 funds for which mandate records gave adequate coverage of the fund’s total portfolio allocation. The mandate records show the percentage of each fund’s portfolio allocated to a specific manager. We hold patterns of allocation derived from the mandate data constant throughout the 3 year sample, since we have only one set of mandate records currently available and the average length of a mandate contract is three years.

The number of mandates per fund in our sample ranges from 59 to 1. The first, second and third quartile markers for the mandate distribution fall
at 5, 12 and 21 mandates, so for the purposes of easier comparison we divide
the funds into four (unequal) groups. The first group includes 45 funds with
22-59 mandates, the second includes 46 funds with 13-21 mandates, the third
group includes 52 funds with 6-12 mandates and the fourth group includes
55 funds with 1-5 mandates.

Size of fund and mandate number are positively correlated ($\rho = 0.46$)
as is evident in Figure 2, but there are a number of large funds with few
mandates and vice versa.

In the Rainmaker database mandates are identified by manager name
and asset class. Where possible, we make a precise match between mandate
and manager, allowing us to match 61 per cent of mandates exactly. In
the event that a precise match is not possible, we substitute a proxy return
based on an average return to all managers in that asset class, or in the case
of cash and private equity, we substitute an index return. In addition, since
diversified fund returns are reported net of fees but specialised funds are
not, we add back the equivalent of 0.5 per cent p.a. to returns to diversified
funds to account for fee deductions. The asset classes and proxies are set
out in Table 1.

We combine mandate weights and manager returns to compute a monthly
portfolio return for each of the 198 superannuation funds, for the sam-
ple period January 2002 to December 2004 (a total of 36 observations for
each fund) which means that superannuation fund portfolio returns are a
weighted average of the manager returns and/or the return to the proxy.

We look at the question of decentralised management efficiency from two
perspectives: we first compare the performance of funds against each other,
gathering information on whether there are measurable differences between
the funds according to the number of mandates they issue; then we compare
existing funds against an objective performance standard, testing whether
they perform well against a well-diversified portfolio of asset class indices
via a series of spanning tests and simulations. (The technical derivation of
spanning tests under short-sales constraints is outlined in Appendix B.)

The next two sections describe the performance tests we applied, and
report the empirical results, first comparing superannuation fund with fund
and then comparing funds with benchmarks.
5 Empirical evaluation: fund vs. fund

We begin by looking at the return and risk profile of each of the 198 individual funds in the sample, listed by the number of mandates they issue, then review the performance of four quartile groups where group 1 has the most and group 4 the least mandates. We assume that the aim of superannuation funds in issuing mandates is to improve risk-adjusted return (net of fees) to investment, either through diversification of judgment, so that negative impacts from prediction errors of any single active manager are lessened by adding managers to the central fund, and/or through diversification of style, so that the active skills of specialist managers are combined. If these strategies are effective, we would expect to see smoother and higher returns among funds issuing more mandates.

It is natural to expect that costs are higher for superannuation funds with more mandates, due to the higher administrative costs of tendering for, and keeping track of, more mandates. We also expect higher investment fees as greater specialisation and expertise are required from managers, and as the superannuation fund assets are broken down into smaller sub-groups, lowering economies of scale. We currently do not have the relevant data to address these important issues so we restrict our investigation to returns comparisons. To the extent that differences between investment returns and crediting rates to members accounts are a guide to fees and costs, some indication is provided in Section 6.

5.1 Individual fund risk and return

Figure 3 shows average annual investment returns over the three years to December 2004 for all 198 not-for-profit superannuation funds. The average annual return across all 198 funds was 6.65 per cent, with the highest return above 12 per cent and the lowest return under 3 per cent. The mean return appears to decline as mandate numbers decrease, suggesting that mandate numbers are positively correlated with investment returns. (This result will be shown more precisely when we review group performance below.)

[INSERT FIGURE 3 HERE]

Risk levels do not show a clear trend (Figure 4), being centred on an average of 6 per cent p.a., with the most risky fund showing a standard deviation slightly below 9 per cent, and the least risky, a standard deviation
close to 2.5 per cent. Funds in the 12-6 mandates range have the highest risk, while funds in the 13-22 mandate range have the least.

Figure 5 graphs the returns to risk ratios, showing a small downward trend and/or break around the 12 mandates mark, and indeed the average return to risk ratio for funds with more than 12 mandates is 1.3, while the average for funds with 12 or fewer is 1.00.

Overall fund with fund comparison points to benefits from diversifying across more manager mandates. However the returns and risk are not linearly related to number of mandates, since the most unpredictable and potentially poor outcomes are in the 6-12 mandates region, and the best risk-adjusted outcomes are in the 13-22 mandates region.

5.2 Grouped risk and return

The small number of time series observations available for each superannuation fund portfolios makes more rigorous testing difficult at the individual fund level. We would like to take the testing further, so we arbitrarily divide the funds into approximate quartiles (as outlined in Section 4), stacking returns for all the funds in each division, and artificially creating four series of portfolio returns.\(^8\) Table 2 sets out summary statistics for each of the four groups of funds. Mean returns are highest for the funds with the most mandates and least for the funds with the least mandates, but standard deviations do not decline evenly as mandate numbers increase: the 13-21 mandate group is least risky, and the 6-12 mandate group is most risky. Negative skewness (indicating a long left tail in the returns distribution) gets worse as mandate numbers increase from 6 to 59, but kurtosis seems unrelated to mandates.\(^9\)

One implication of diversification across managers is that returns should be less volatile as trustees diversify across specialists. To formally compare the volatility of different mandate groups we test for significant difference

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\(^8\)Stacking returns in blocks preserves temporal dependence across the four groups.

\(^9\)In a related study into equity fund of funds in Australia, Brands and Gallagher (2003) find that negative skewness and kurtosis worsen as managers are added to a fund of equity funds.
between realised volatilities. We compute portfolio realised variances as squared excess returns \( \left\{ \left( \mu_i^2 \right)^2 \right\}_{i=1}^4 \) at each time period \( t \), in the sample, for each of the groups \( i = 1, \ldots, 4 \). Returns are net of the 30-day risk-free rate for \( t \). For each possible pairing of groups \( (ij) \), we then compute the difference

\[
u_{ij}^t = \left( \mu_i^2 \right)^2 - \left( \mu_j^2 \right)^2, \quad i \neq j
\]

forming \( \{u_{ij}^t\}_{i,j=1,i\neq j}^4 \).

The null hypothesis is that the mean of each \( u_{ij}^t \) series is zero, indicating that no reduction in portfolio volatility accrues as mandates are added to portfolios. We test this hypothesis by a t-test on the coefficient \( \beta \) in the regression \( u_{ij}^t = \beta \epsilon_t + \varepsilon_t \) where \( \epsilon \) is a vector of ones (Table 3). The first column reports tests of volatility of group 4 less volatility of groups 3, 2, and 1. Positive values indicate that the variance of group 4 is larger than the comparison group, and negative values indicate the reverse. Significantly smaller variances are obtained in the two largest mandate groups, but there is no significant volatility difference between groups 3 and 4. Funds with 13-21 mandates have smaller volatility than funds with 22-59 mandates, as shown by the significant negative coefficient in the last column. Overall, the least risky returns are obtained in the 13-21 mandate range, with no significant reduction in risk from more mandates. In addition, moving from the 1-5 to the 6-12 range creates no significant improvement for investors.

[INSERT TABLE 3 HERE]

Retirement savers are interested in both return and risk, so we shift focus to tests of stochastic dominance. Our aim is to test whether differences between realised portfolio returns are likely to matter to a risk averse investor, or whether in fact investors would be indifferent between the groups. For any two samples of portfolio returns \( \{ \mu^i \} \) and \( \{ \mu^j \} \) with cumulative distributions (CDFs) \( G \) and \( F \), then portfolio \( i \) will be preferred by portfolio \( j \) by any agent whose utility over returns exhibits risk aversion (so that \( U(\mu) \) obeys \( U'(\mu) \geq 0 \), and \( U''(\mu) \leq 0 \)) when \( \int_t^\infty G(t)dt \leq \int_t^\infty F(t)dt \) for all \( \mu \). The null hypothesis to be tested is that \( G \) weakly dominates \( F \) in the second degree. Under the Barrett and Donald (2003) framework the CDFs are evaluated at all points in the support.\(^\text{10}\) Under the null hypothesis the

\(^{10}\)We refer the reader to Barrett and Donald 2003 for an explicit discussion of the test statistic and its sampling distribution.
test statistic is no greater than zero. The sampling distribution of the test statistic is generating by bootstrapping using the block bootstrap method of Lim, Maasoumi and Martin (2004) to allow for contemporaneous and serial dependence in the data.

Table 4 reports test results. We establish the dominance of portfolio returns $i$ over $j$ when the null hypothesis is accepted for $i$ tested against $j$ but rejected when the hypothesis is reversed. If we can reject neither null, the test is inconclusive. Returns from the 22-59 mandate group dominate returns from all other groups, and would be preferred by risk averse consumers. Group 2 is also clearly preferred to the small-mandate groups, but we found no clear ordering over returns to the 1-5 and 6-12 groups.

Comparing groups with groups shows advantages to members of funds who invest in 13 or more managers. These funds show significantly less volatility and overall higher returns than the funds choosing less than 13 mandates. However at the lower end of the spectrum, no significant advantages accrue to members of funds who choose between 6-13 managers rather than a small number, or even one, diversified manager.

6 Empirical evaluation: fund vs. benchmark

The essence of performance assessment is to ‘investigate whether a fund manager helps enlarge the investment opportunity set faced by the investing public and, if so, to what extent the manager enlarges it ’(Chen and Knez 1996). To make this measurement we need to test the funds here against a benchmark of the investment opportunity set faced by superannuation investors, rather than simply comparing one fund against another.

6.1 Benchmark selection

Our goal in choosing a benchmark is to span as efficiently as possible the investment opportunity set faced by trustees. As a minimum we expect that the portfolios offered by superannuation trustees should be as efficient as one which a well-informed investor could construct for themselves. Following Elton, Gruber and Blake (2004), we choose a set of asset class indices to form a benchmark portfolio from among equities, property, fixed interest and cash. (Table 5 gives summary statistics, and a full description of sources is given
in Appendix A.) We include both domestic and international equities and fixed interest indices: we divide domestic equities by size and value/growth divisions, and domestic fixed interest securities into composite and indexed classes. Of the asset indices tested, listed property has the highest average, and world equity markets the lowest average, returns over the sample.

[INSERT TABLE 5 HERE]

6.2 Spanning tests: mandate funds

The benchmark portfolio is used in two sets of tests. Firstly we test whether any superannuation fund portfolio spans the space of the benchmark indices, in other words, whether an investor holding a superannuation portfolio could do no better in risk-adjusted terms by adding the benchmark indices to his or her portfolio. The null hypothesis is that:

\[ \alpha \leq 0 \]  

where \( \hat{\alpha} \) is the vector of constants from the regression of excess returns on the benchmark indices (\( r_{b,t} \)) on excess returns over the fund portfolio returns (\( r_{i,t} \)). If \( \alpha = 0 \) then the superannuation fund portfolio is as efficient as any linear combination of benchmark indices.

We run the least-squares regressions of the benchmark indices on each fund return

\[ r_{b,t} = \alpha + \beta r_{i,t} + \varepsilon_t, \]  

computing 12 equations for each of the 198 superannuation funds. We then test the null hypothesis that \( \alpha \) from the 12 equations are jointly zero via a Wald test. (Results are reported in Table 6.) To allow for the fact that superannuation portfolios are restricted in short sales, we use critical values for the Wald test that allow for this inequality constraint, as discussed by De Roon et. al. (2001) and derived by Kodde and Palm (1986). (Appendix B gives details of the test procedure.)

[INSERT TABLE 6 HERE]

Test results from Table 6 indicate that none of the 198 fund portfolios spanned the benchmark of assets, which is some evidence of inefficient portfolio choice by trustees.

[INSERT TABLE 7 HERE]

As an alternative, we conduct the same spanning test against an equally
weighted portfolio of benchmark assets. In this case the null hypothesis that \( \alpha \leq 0 \) can be tested by a one-tailed t-test, and results are shown in Table 7. Funds for which the null hypothesis of spanning cannot be rejected are marked as grey-shaded cells. Of the 198 funds, 46 span the equally-weighted benchmark, particularly among the higher mandate groupings. In fact, almost half of the 22-59 mandate group span the equally-weighted benchmark, and more than one third of the 13-21 mandate group. (See Table 8.) In terms of terminal wealth over 20 years, a superannuation portfolio which returned the average of the 198 represented here would generate around 16 per cent less than the equally weighted benchmark portfolio.

\[ \text{[INSERT TABLE 8 HERE]} \]

In summary, superannuation fund portfolio returns are inefficient compared with an efficiently diversified portfolio of indices, but about one quarter of superannuation funds perform at least as well as an equally-weighted portfolio of indices. Funds having more than 13 mandates are more likely to match equally-weighted benchmark performance, and the probability of matching the index rises as mandates rise above 22.

### 6.3 Spanning tests: simulated funds

Finally, to gauge the ability of trustees to choose from the universe of investment managers we test some randomly selected portfolios from the investment manager pool against the equally-weighted benchmark. There are a total of 362 specialised investment managers whose returns are available in the Rainmaker database. Of these 114 are Australian equities managers, 47 are Australian fixed interest managers, 49 are Australian property managers, 121 are international equities managers, 26 are international fixed interest managers and 5 are hedge funds. (We leave diversified managers out of the simulation.) We form 100 random selections of pre-specified size from this pool of managers and then compute equally weighted portfolios. We test returns from simulated equally-weighted portfolios against the returns from an equally-weighted benchmark for spanning, and we report the proportion of the 100 simulations for which we could not reject the null hypothesis of \( \alpha \leq 0 \).

In the first round we allow random selections from the pool of investment managers to be unconstrained, with all managers equally likely to be selected. (Table 8). Unconstrained random selection implies that the asset
classes with the highest representation in the manager pool are most likely to be selected. Since the largest group are international equity managers, which generated poor returns over this sample, it is perhaps not surprising to find that when we add more managers to a portfolio performance against the benchmark gets worse.

[INSERT TABLE 8 HERE]

Compared with the actual outcomes for the superannuation portfolios however, the random selection process uncovers some interesting features. The proportion of portfolios spanning the equally-weighted benchmark is much higher among random selections in the 6-12 manager (mandate) range (above 30 per cent), than it is among actual superannuation portfolios in this mandate range (13 per cent). By contrast, randomly selected portfolios in the 13-20 range show lower likelihood of spanning than the actual superannuation portfolios in this range (29 per cent as compared with 35 per cent), and given the downward trend in the random selection spanning rates, the top-end group of actual superannuation portfolios did better.

In the second round we forced the allocation to include at least one investment manager from Australian equity, fixed interest, and property, and international equity and fixed interest. After selecting a manager from each of those asset class groups, we added managers at random without restrictions. Forcing asset class diversification greatly increases the likelihood that a randomly selected portfolio of managers will test well against the equally-weighted benchmark, but again the likelihood of spanning declines as managers are added. The performance of the actual superannuation portfolios is worse than the diversified random selections for all but the top group.

To summarise, these simulation exercises indicate that trustees of superannuation funds with more than 13 mandates did better than a randomly selected equally weighted portfolio, drawing from the same pool of investment managers. Results were less convincing when we constrained random selections to minimal asset class diversification - in that case, only the superannuation funds with the largest number of mandates could perform better than equally weighted diversified random selection.

We can think of the random selection process as mimicking the choices of an uninformed individual selecting from a 401K plan or retail superannuation fund menu. These results show that trustee selections are no better over this sample than an individual following a naive diversification strat-
egy where she chooses a manager from each asset class and then weights her portfolio equally.

6.4 Fees, charges, taxes and smoothing

Of ultimate concern to superannuation fund members is not the raw investment returns available to trustees for distribution, but crediting rates received on member accounts. Here we compare averages of reported crediting rates for the year to June 2004, with the annual raw investment return gained over the same period.\textsuperscript{11} Series for individual funds are shown in Figure 6.

\textbf{[INSERT FIGURE 6 HERE]}

The correlation between investment returns and crediting rates is remarkably weak at the individual fund level, and the actual correlation coefficient is 0.12. Accounting for some gap between investment returns and crediting rates is not so difficult: manager fees, taxes, administrative expenses and other costs all may contribute to differences between investment earnings and crediting rates. What is harder to explain is the volatility of the gap between the two series on a fund by fund basis, since one would expect most not-for-profit superannuation funds to face similar taxes, fees and expenses, conditional on asset allocation.

Grouping the funds and averaging as we do in Figure 7 smooths away the volatility, but exposes another anomaly: while the 59-22 mandate group generates the highest investment return, it does no better on crediting rates than the 1-5 mandate group (11.8 as compared with 11.75 per cent p.a.). The lowest crediting rates apply to the 6-12 mandate group (10.21 per cent p.a.), but the actual variation from group to group is small.

\textbf{[INSERT FIGURE 7 HERE]}

We cannot draw a strong conclusion from this single and approximate data point, but these results do raise doubts as to how much of any diversification benefits from mandate proliferation is being passed on to members of superannuation funds.

\textsuperscript{11}Most superannuation funds report crediting rates annually. Crediting rates shown in Figure 6 and 7 are reported in Rainmaker Market Place. Where information on the proportion of total funds held in each account option was available, the crediting rate is a weighted average of separate account crediting rates. If funds did not report option weights, then an average of option crediting rates is reported.
Conclusions

This paper began with the theoretical observation that decentralised investment management is likely to be inefficient, but that managers of large pools of funds in financial markets behave as if the opposite were true. In the USA, for example, managers of 401K plans act as a filter on the mutual fund industry, selecting a group of managers that plan members may invest in. For Australia, the trustees of not-for-profit superannuation funds are responsible for investing contributions, but increasingly have passed the job on to specialised investment managers via investment mandates. This trend raises a series of questions: Does this additional layer of management, where trustees pool contributions and then disperse them among investment funds, create value for retirement savers? Is there a pattern of increasing benefit as the number of managers (mandates) increases? Do these delegated investment funds do better than a group of standard asset indexes? Are they able to choose managers with more skill than an uninformed individual? Are the benefits, if they exist, passed on to members’ accounts via realised crediting rates?

Using a unique data set from Rainmaker Information, we create mandate-based investment portfolio returns for 198 not-for-profit superannuation funds, generating 36 monthly investment returns for the three years to December 2004. We attempt to answer the questions for the first time via a series of statistical comparisons and performance tests.

Results of portfolio against portfolio comparisons suggest that superannuation funds who employ more than 13 managers did better on a risk-adjusted return basis than funds with fewer managers. The differences in risk are statistically significant between the groups with 13 or more managers and those with less, but no significant difference can be detected for those funds with 6-12 managers and those with fewer. Worst performance over the sample period is associated with funds who had 6-12 managers.

However when we compared superannuation portfolio returns with returns to a diversified portfolio of asset class indices, spanning tests showed that none of the 198 funds were as efficient as an optimally positively weighted portfolio of indices. Superannuation portfolios with 22-59 mandates did perform as well as an equally-weighted portfolio of indices in about 50 per cent of cases, and about 30 per cent of cases for portfolios made up
of 13-21 mandates. This compares with the findings of Elton, Gruber and Blake (2004) that about 38 per cent of 401K plans in their sample spanned the returns space of eight asset class indices.

When we built portfolio of randomly selected investment managers from the same pool as used by superannuation funds, results showed that actual superannuation portfolios with many mandates did better than the randomly generated equally-weighted portfolios, but those with fewer mandates did worse. However once we constrained the randomly generated portfolios to match minimal asset class diversification, actual portfolio performance was rarely better than chance selection. Since the random selection process mimics the choices of an uninformed individual selecting from a 401K plan or retail superannuation fund menu, results show that trustee selections are no better over this sample than an individual following a naive diversification strategy of choosing at least one manager from each asset class at random.

Taken as a whole, the evidence for mandate-based delegated investment in the Australian retirement savings system is, at best, mixed. Compared with other superannuation funds, funds with very high rates of mandate issuance add value in risk-adjusted returns, and probably perform as well as a naively constructed benchmark portfolio. However these advantages appear to accrue only to funds with very large and sophisticated delegation structures. On the contrary, adding a few specialist managers to a portfolio does not appear to improve on diversified investment and does no better than random investment manager selection over the sample we investigate. What is not at all clear at this stage of research is the extent to which gains to mandated investment are diluted by the higher expense of engaging and administering large and complex portfolios.

Data constraints prevent us conducting a rigorous comparison between crediting rates to members retirement savings accounts and actual investment returns, but using the little data that is available raises some puzzles. The correlation between crediting rates and investment returns is very low at the individual fund level. When we pool investment returns and crediting rates into quartile mandate groups, we find that diversification gains from employing more investment managers may be being consumed in fees, costs or smoothing.
Appendix A: Benchmark data

Australia:

- Large-cap equities: S&P/ASX 50 total returns index ASX5LD(RI)~A$, DataStream
- Mid-cap equities: S&P/ASX MIDCAP50 total returns index ASXM50I(RI)~A$, DataStream
- Small-cap equities: ASX Small ordinaries total returns index ASXSORD(RI)~A$, DataStream
- Value equities: MSCI Australia Value Gross Index, local currency, MSCI http://www.msci.com/equity/index2.html
- Growth equities: MSCI Australia Growth Gross Index, local currency, MSCI http://www.msci.com/equity/index2.html
- Property: GPR General PSI Australia total returns index GPRGALL(RI)~A$, DataStream
- Cash: UBS Australian Bank Bills ABNKBLI(PI)~A$, DataStream
- Fixed Interest composite: UBS Composite All Maturities total returns index, ACIALL(RI)~A$, DataStream
- Fixed Interest indexed: UBS Govt. Inflation All Maturities total returns index, AIALLM(RI)~A$, DataStream

International:

- World equities: World ex Australia Gross Index, local currency, MSCI http://www.msci.com/equity/index2.html
- Emerging markets: MSCI Emerging markets total returns index, MSEMKF$(RI)~A$, DataStream
- Fixed Interest: Salomon Bros. CGBIWGBI All Maturities (A$ Hedged) SBWGTC(RI)~A$, DataStream

Risk-free rates:

Appendix B: Derivation of spanning tests

Following De Roon et. al. (2001) and Bekaert and Urias (1996), again consider a set of $N$ risky assets with net returns $r_i$, $i = 1, 2, \ldots N$. Let gross returns be indicated by $R_{t+1} = \eta_N + r_{t+1}$, and $R_{t+1}$ and $r_{t+1}$ are also $N \times 1$. Investors hold portfolios with weights $w \in C \subset \mathbb{R}^K$, so that the potential portfolio returns set is given by:

$$X = \{ R_{t+1}^P : R_{t+1}^P = w'R_{t+1}, w \in C, w'1 = 1 \}$$

If there are no market frictions and the law of one price holds, there exists a stochastic discount factor $m_t$ (equal to an individual’s marginal rate of substitution) which satisfies the general pricing condition:

$$E[R_{t+1}m_{t+1}|\Phi_t] = \eta_N,$$  \hspace{1cm} (13)

or

$$E[r_{t+1}m_{t+1}] - E[m_{t+1}] - \eta_N = 0.$$  \hspace{1cm} (14)

The minimum variance value of $m_{t+1}$ is given by the linear projection of $m_{t+1}$ on the vector of returns, according to Hansen and Jagannathan (1991), so that

$$m_{t+1}^v = v + [r_{t+1} - E(r_{t+1})]' \beta^v$$  \hspace{1cm} (15)

$$E(m_{t+1}^v) = v$$  \hspace{1cm} (16)

$$\beta^v = \text{var}(r_{t+1})^{-1} [\eta_N(1-v) - vE(r_{t+1})].$$  \hspace{1cm} (17)

Further, the portfolio $w_\beta = \beta^v / (\beta^v \eta_N)$ is a mean-variance efficient portfolio.

From equation (3), the tangency portfolio is

$$w = \frac{1}{\eta_N \Omega^{-1} (E(r) - r_f)} \Omega^{-1} (E(r) - r_f).$$  \hspace{1cm} (18)

The portfolio $w_\beta = \beta^v / (\beta^v \eta_N)$ can be written in this form. Allowing $v = 1 / (1 + r_f)$, then
\[ w_\beta = \frac{\beta^\prime}{(\beta^\prime \lambda_N)} \]
\[ = \frac{-1}{-\lambda_N \Sigma^{-1} (E(r_{t+1}) - r_f)} \Sigma^{-1} (E(r_{t+1}) - r_f) \]
\[ = \frac{1}{\lambda_N \Sigma^{-1} (E(r_{t+1}) - r_f)} \Sigma^{-1} (E(r_{t+1}) - r_f) \]
\[ = w. \]

Hence the mean-variance tangency portfolio and the portfolio proportional to the Hansen-Jagannathan beta are the same.

De Roon et. al. (2001) rewrite the general asset pricing equation (13) for the case where short sales are excluded. They restrict choice over \( w \in C \subset \mathbb{R}^K_+ \) by

\[ E[R_{t+1}m_{t+1} | \Phi_t] \leq \lambda_N \] (19)

Drawing from Sharpe (1991), De Roon, et.al. outline the effect on the optimal mean-variance frontier of restricting short sales. The problem set out in equations (1) and (2) above includes the additional constraint:

\[ w_i \geq 0, \forall i. \] (20)

The new Lagrangian can be written as:

\[ L_i = \frac{1}{2} w \Sigma w + \lambda [E(r_p) - w'E(r) - (1 - w'\lambda_N)r_f] + \delta_i [-w_i], \forall i \] (21)

and the Kuhn-Tucker conditions give:

\[ \Omega w - \lambda (E(r) - \lambda_N r_f) - \delta = 0, \]
\[ w_i^*, \delta \geq 0, \forall i \]
\[ w_i^* \delta = 0, \forall i \] (22)

The multipliers \( \delta_i \) on the non-negativity constraints will be zero for any asset weights for which the short-sales constraint is not binding. Using this
result, De Roon et al. note that there is a subset of assets of dimension $L$ with returns vector $\mathbf{R}^{(l)}$ for which the short-sales constraint is not binding at this value of $E(r_p)$. Denoting $r_f = 1/l$, where $l = E(m^*)$, for the $m^*$ which prices $\mathbf{R}^{(l)}$ correctly, they then argue that the mean-variance efficient portfolio given by the Kuhn-Tucker conditions (22) above is the same as the mean-variance efficient portfolio without short-sales constraints, but using only the assets in $\mathbf{R}^{(l)}$. They derive two important relations:

$$E \left[ r^{(l)} \right] - \frac{1}{l} l_L = \left( \Omega^{(l)} \right) \mathbf{w}^{(l)}$$

$$E \left[ r^{(l)} \right] - \frac{1}{l} l_L + \delta = \text{covar} \left( r, r^{(l)} \right) \mathbf{w}^{(l)}$$

where $\text{covar} \left( r, r^{(l)} \right)$ is the covariance between the full returns vector and the subvector containing only those assets for which the short-sales constraint is not binding. The stochastic discount factor that prices the returns vector under short-sales constraints is

$$m_{t+1}^l = l + \left[ r_{t+1}^{(l)} - E \left( r_{t+1}^{(l)} \right) \right]' \beta'$$

$$\beta' = \text{var} \left( r_{t+1}^{(l)} \right)^{-1} \left[ l_L (1 - l) - l E \left( r_{t+1}^{(l)} \right) \right].$$

We use this definition of $m_{t+1}^l$ to outline spanning tests. Mean-variance spanning holds for an additional set of $K$ assets with returns vector $\mathbf{R}_a$ if the same stochastic discount factor that prices $\mathbf{R}$ also prices $\mathbf{R}_a$ correctly. This implies that,

$$E \left[ \mathbf{R}_{a,t+1} m_{t+1}^l \right] \leq \iota_K,$$

and using the expressions above to get,

$$l \left[ E(r_{a,t+1}) + l_L \right] + \text{cov} \left( r_{a,t+1}, r_{t+1} \right) \text{var} \left( r_{t+1}^{(l)} \right)^{-1} \left[ l_L (1 - l) - l E \left( r_{t+1}^{(l)} \right) \right] \leq \iota_K.$$

If short-sales constraints apply to both $r_{t+1}$ and $r_{a,t+1}$, then the spanning test is equivalent to the restriction that in the regression
\[ R_{a,t+1} = a^{(l)} + B^{(l)} R_{t+1}^{(l)} + \varepsilon_{t+1}^{(l)}, \]  
(28)

it is true that

\[ l\alpha^{(l)} + (B^{(l)} \mu_L - \mu_K) \leq 0. \]  
(29)

Where there is a risk-free asset, the regression can be constructed in terms of excess returns:

\[ r_{a,t+1} - r_{f,K} = \alpha + \gamma (r_{t+1} - r_{f,L}) + \epsilon_{t+1} \]  
(30)

and it can be shown that

\[ \frac{1}{r_f} \alpha = \frac{1}{r_f} \alpha^{(l)} + (B^{(l)} \mu_L - \mu_K) \leq 0. \]  
(31)

So the spanning test can be conducted under the null hypothesis that:

\[ \alpha \leq 0 \]  
(32)

where \( \hat{\alpha} \) is the vector of constants from the regression of excess returns over \( r_{a,t+1} \) on excess returns over \( r_{t+1} \). Again the short-sales constraints restrict the choice of benchmark assets to those positively weighted in the optimal portfolio.

De Roon et al. draw on the analysis of Kodde and Palm (1986) and Gourieroux, Holly and Monfort (1982) to define the Wald test of the restriction given by (29) above. They define the test statistic:

\[ \xi(l) = \min_{\alpha \leq 0} (\hat{\alpha}(l) - \alpha(l))^t \text{var} [\hat{\alpha}(l)]^{-1} (\hat{\alpha}(l) - \alpha(l)) \]  
(33)

which is asymptotically distributed as a mixture of \( \chi^2 \) distributions. The difficulty in these types of test arises from computing the large sample distribution of the test statistic under an inequality constraint. They note that the probability of \( \xi(l) \geq c \) is given by:

\[ \Pr \{ \xi(l) \geq c \} = \sum_{i=0}^{K} \Pr \{ \chi^2 \geq c \} \omega(K, i, \text{var} [\hat{\alpha}(l)]) \]  
(34)

The weights \( \omega(\cdot) \) are the probabilities that, for a \( K \) vector distributed \( N(0, \text{var} [\hat{\alpha}(l)]) \), \( K - i \) elements are strictly negative. The weights can be
simulated numerically according to Gourieroux, Holly and Montfort (1982), but De Roon et. al. recommend the use of tables supplied by Kodde and Palm (1986) which give upper and lower bound critical values for a given significance level.
References


Cogan, J. and Mitchell, O.S. (2003), ‘Perspectives from the President’s Commission on Social Security Reform,’ *Journal of Economic Perspectives*, 17(2).


Table 1: List of proxies for non-matching mandates

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Number of Managers</th>
<th>Proxy</th>
<th>Sample average return, p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Equity</td>
<td>114</td>
<td>Average of managers</td>
<td>7.58%</td>
</tr>
<tr>
<td>Australian Fixed</td>
<td>47</td>
<td>Average of managers</td>
<td>1.39%</td>
</tr>
<tr>
<td>Property</td>
<td>49</td>
<td>Average of managers</td>
<td>11.30%</td>
</tr>
<tr>
<td>International Equity</td>
<td>121</td>
<td>Average of managers</td>
<td>-7.64%</td>
</tr>
<tr>
<td>International Fixed</td>
<td>26</td>
<td>Average of managers</td>
<td>3.43%</td>
</tr>
<tr>
<td>Hedge</td>
<td>5</td>
<td>Average of managers</td>
<td>13.75%</td>
</tr>
<tr>
<td>Diversified</td>
<td>107</td>
<td>Average of balanced diversified managers</td>
<td>5.61%</td>
</tr>
<tr>
<td>Private Equity</td>
<td>-</td>
<td>Datastream Australian small cap equities index</td>
<td>12.65%</td>
</tr>
<tr>
<td>Cash</td>
<td>-</td>
<td>Datastream Bank Bills index</td>
<td>4.99%</td>
</tr>
<tr>
<td>Currency</td>
<td>-</td>
<td>Assumed zero</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>Average of balanced diversified managers</td>
<td>5.61%</td>
</tr>
</tbody>
</table>

Table 2 Summary statistics, pooled monthly returns, annualised

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22-59 Mandates</td>
<td>13-21 Mandates</td>
<td>6-12 Mandates</td>
<td>1-5 Mandates</td>
</tr>
<tr>
<td>Mean</td>
<td>9.87</td>
<td>9.17</td>
<td>8.45</td>
<td>8.14</td>
</tr>
<tr>
<td>Median</td>
<td>12.61</td>
<td>11.46</td>
<td>11.07</td>
<td>11.17</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>6.08</td>
<td>5.82</td>
<td>6.30</td>
<td>6.18</td>
</tr>
<tr>
<td>Reward to risk</td>
<td>1.62</td>
<td>1.58</td>
<td>1.34</td>
<td>1.32</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.32</td>
<td>-0.28</td>
<td>-0.24</td>
<td>-0.31</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.32</td>
<td>2.36</td>
<td>2.32</td>
<td>2.31</td>
</tr>
</tbody>
</table>

Notes: Statistics calculated from annualised monthly returns for all superannuation funds in each group. Group 1 includes 1620 observations, Group 2 includes 1656, Group 3 includes 1872 and group 4 includes 1980 observations.
Table 3: Difference in portfolio variance, groups 1-4.

<table>
<thead>
<tr>
<th>Portfolio i</th>
<th>1-5 Mandates</th>
<th>6-12 Mandates</th>
<th>13-21 Mandates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio j</td>
<td>Coefficient</td>
<td>t-stat</td>
<td>Coefficient</td>
</tr>
<tr>
<td>6-12 Mandates</td>
<td>-0.056</td>
<td>-0.496</td>
<td></td>
</tr>
<tr>
<td>13-21 Mandates</td>
<td>0.457</td>
<td>3.880</td>
<td>0.648</td>
</tr>
<tr>
<td>22-59 Mandates</td>
<td>0.179</td>
<td>1.806</td>
<td>0.383</td>
</tr>
</tbody>
</table>

Notes: Estimated coefficients in the regression of \( u_{ij} \) on a constant, where \( u_{ij} \) is the difference between realised volatility of portfolio \( i \) and portfolio \( j \) at each observation. A significant positive value indicates that the variance of portfolio \( i \) exceeds the variance of portfolio \( j \). A significant negative value indicates that the variance of portfolio \( i \) is smaller than the variance of portfolio \( j \). \( t \)-statistics are based on robust (Newey-West) standard errors.

Table 4: Tests for second degree stochastic dominance, groups 1-4.

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<th>Portfolio i</th>
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<td>0.89</td>
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Notes: Test that portfolio \( i \) dominates portfolio \( j \) in the second degree in the left hand column and corresponding test that portfolio \( j \) dominates portfolio \( i \) in the right hand column. A high p-value indicates failure to reject the null hypothesis that \( i \) dominates \( j \) (or the reverse). Significant p-values are marked with an asterisk.

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Table 6: Unrestricted spanning tests of individual fund portfolios against asset class indices.

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Notes: Table reports Wald test statistic for the null hypothesis that constants in the regressions of indices against individual superannuation fund portfolios are jointly zero i.e. that superannuation fund portfolios span the asset class indices. Critical value under short-sales constraint with 12 degrees of freedom is 20.47 according to Kodde and Palm (1986), indicating that the null is rejected for all superannuation funds.
Table 7: Spanning test of individual superannuation fund portfolios against an equally-weighted portfolio of indices.

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</tbody>
</table>

Notes: Table reports t-test statistic for the null hypothesis that the constant in the regression of returns to an equally weighted portfolio of indices against returns to individual superannuation fund portfolios is zero, i.e. that fund portfolios span the equally-weighted index portfolio. Critical value for the one-tailed test is 1.69. t-statistics less than 1.69 are shaded grey.
Table 8: Proportion of funds in each mandate group spanning equally-weighted portfolio of indices.

<table>
<thead>
<tr>
<th>Number of funds spanning</th>
<th>% of group spanning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (funds 1-45) 22-59 mandates</td>
<td>21</td>
</tr>
<tr>
<td>Group 2 (funds 46-91) 13-21 mandates</td>
<td>16</td>
</tr>
<tr>
<td>Group 3 (funds 92-143) 6-12 mandates</td>
<td>7</td>
</tr>
<tr>
<td>Group 4 (funds 144-198) 1-5 mandates</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 9: Spanning tests of randomly selected portfolios of investment funds

<table>
<thead>
<tr>
<th>Number of funds per portfolio</th>
<th>% of simulated portfolios spanning index portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Random selection</td>
</tr>
<tr>
<td>6</td>
<td>41</td>
</tr>
<tr>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>10</td>
<td>31</td>
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<td>12</td>
<td>32</td>
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<td>14</td>
<td>29</td>
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<tr>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>20</td>
<td>27</td>
</tr>
</tbody>
</table>

Notes: Random selection of investment funds were made from the mandate manager pool and formed into equally-weighted portfolios. The first column reports the proportion of these funds spanning the equally-weighted portfolio of indices from 100 hundred simulations where any combination of investment managers could be chosen. The second column reports the proportion of these funds spanning when the random selections were constrained to choose at least one manager from Australian equity, fixed interest and property, and international equity and fixed interest, and then make random selections for remaining funds.
Figure 1: Structure of funds management in superannuation

- Member Contributions
  - Investment Options
    - Capital Stable
    - Balanced
    - Growth
    - Asset classes
  - Trustees
    - Asset consultant
    - Investment mandates
      - Domestic stocks
      - Domestic Fixed
      - Property
      - International stocks
      - International Fixed
      - Diversified
      - Cash
  - Investment returns
    - Crediting rates
      - Taxes, fees, costs, smoothing
      - Asset classes
      - Cash
      - Capital Stable
      - Balanced
      - Growth
      - Asset classes
Figure 2: Mandate number and size of superannuation fund

![Manager number by Fund Size](image)

Figure 3: Average annual investment returns to individual superannuation funds.

![Average annual investment return by individual fund](image)
Figure 4: Standard deviation of monthly individual superannuation fund returns

![Graph showing annualised standard deviation of monthly return by individual fund, Jan 2002 - Dec 2004.](image)

Figure 5: Ratio of annual return to standard deviation by individual superannuation fund

![Graph showing return to risk ratio by individual fund.](image)
Figure 6: Reported crediting rate and investment return for the year to June 2004.

Notes: Crediting rates calculated as a value-weighted average of crediting rates to member ‘options’ where values were available; otherwise as an equally-weighted average of reported crediting rates. Funds not reporting any crediting rates were omitted. Investment returns calculated as a value-weighted average of returns to individual mandates. Source: Rainmaker database.

Figure 7: Average of crediting rates and investment returns for large to small mandate groups.

Notes: Crediting rates and investment returns calculated according to data in Figure 4 and averaged across each mandate group. Source: Rainmaker database.