NZSUPERFUND
Te Kaitiaki Tāhua Penihana
Kaumatua ō Aotearoa

2015 Reference Portfolio Review

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Table of Contents

The 2015 Reference Portfolio

The Guardians of New Zealand Superannuation (Guardians), the investment manager of the New Zealand Superannuation Fund (NZSF or the Fund), has adopted a reference portfolio approach since 2010. A reference portfolio approach is first and foremost a governance construct designed to facilitate clear decision making and accountability of decisions. The Guardians has undertaken to review the composition of the Fund's Reference Portfolio at least once every five years and concluded such a review in the first half of the 2015 calendar year. This paper presents the 2015 Reference Portfolio review.

What is the Difference between the Reference Portfolio and Strategic Asset Allocation?

The Strategic Asset Allocation (SAA) approach is the most common portfolio construction framework used by institutional investors. An SAA is designed to be the most appropriate portfolio for an investor and usually contains alternatives (e.g. private equity) as well as traditional asset classes. The SAA also provides the design for the overall portfolio structure and tends to be static, in that the allocation to each asset class remains unchanged until the next review.

NZSF's Reference Portfolio differs from the SAA in two key aspects. First, the Reference Portfolio is a simple, low-cost and passive portfolio that contains only traditional asset classes. Decisions about the composition of the Reference Portfolio are made by the Guardians' Board. Second, while the Reference Portfolio is static, it acts as a benchmark for the Fund's actual portfolio. The actual portfolio can deviate substantially from, and is more dynamic in nature than, the allocations in the Reference Portfolio. The decisions to deviate from the Reference Portfolio are delegated to the Fund's management, subject to a clear set of risk limits and guidelines. The Reference Portfolio construct provides the governance structure for making these decisions.

Design Principles of NZSF's Reference Portfolio

The Fund is a long-term and growth-oriented global investment fund which assists the New Zealand (NZ) Government in smoothing the future tax burden of superannuation payments. The Government sets aside some assets now that can be drawn down later, while earning a risk premium by investing these assets in capital markets. The Guardians' mandate is to invest the Fund so as to maximise return without undue risk, while employing best practice portfolio management and avoiding prejudice to NZ's reputation as a responsible member of the world community.

The design principles for NZSF's Reference Portfolio are set out in the table below:

NZSF Reference Portfolio Design Principles

The Reference Portfolio should
▪ Be a simple and low cost portfolio that could be implemented passively; ▪ Be diversified; ▪ Reflect an appropriate risk level for the Fund, given its purpose; ▪ Be relevant to a New Zealand-based investor; ▪ Be an equilibrium construct.

These design principles lead to a portfolio which combines very broad market exposures to global equities and global bonds. The compositions of NZSF's Reference Portfolio in 2010 and in 2015, together with our estimates of their expected return and risk, are shown below.

As a result of the change in the composition of the Reference Portfolio, the Fund's performance expectation is now NZ Treasury Bills plus 2.7% p.a. compared to NZ Treasury Bills plus 2.5% p.a. previously. Appendix 1 sets out the historic performance of the Fund's benchmark versus our long-run expectations of that performance. Appendix 2 provides more detail on these long-run performance expectations.

NZSF Reference Portfolio Allocations

	2010 Reference Portfolio	2015 Reference Portfolio
Developed Market Equities	70%	65%
Emerging Market Equities		10%
NZ Equities	5%	5%
Global Listed Properties	5%	-
Global Fixed interest	20%	20%
Expected Return above Cash	2.5%	2.7%
Risk (Volatility, p.a.)	13.2%	13.5%

In choosing the Reference Portfolio, the NZSF Board considered the following:

- *What level of risk and return is appropriate given the Fund's purpose?*
- *What currency hedging is appropriate?*
- *What are the markets that should be represented in the Reference Portfolio?*
- *Should we hedge inflation risk?*
- *How do we choose benchmark indices?*

We provide a brief discussion of each of these issues in the following sections.

Level of Risk and Return

Since the inception of the Fund in 2003, the Guardians' Boards have regarded a high, but not total, exposure to growth (or equity-like) assets as best fulfilling the mandate of maximising return without undue risk. The 2015 review endorsed this decision and retained the existing Reference Portfolio allocation of 80% to growth assets and 20% to income assets. The Fund's endowment of being a long-term investor with no direct liabilities implies a greater tolerance for equity risk than the typical investor. Furthermore, an allocation to bonds in the Reference portfolio is seen as desirable for diversification reasons.

Currency Hedge Ratio

Historically, we have observed a persistent interest rate differential between the New Zealand dollar (NZD) and a basket of developed market currencies, that is, there is a risk premium for hedging the currency risk of offshore assets to the NZD. The premium is often assumed to reflect risks associated with NZ's narrow export base and high foreign debt.

Our analysis suggests that, in the presence of this NZD currency risk premium, foreign investments should be fully hedged. Even if we were to ignore this risk premium and just consider the impact of currency hedging on the risk of the Reference Portfolio, currency hedging has very limited ability to lower risk. For example, the volatility of the Reference Portfolio would only drop from 13.5% to 13.2% if the hedge ratio were lowered from 100% to the minimum risk point of 75%. Therefore, a relatively small risk premium can easily outweigh the benefit of such a small risk reduction.

Other considerations that are often raised in the hedging decision include the potential for risk of regret, peer risk, concerns regarding the impact on liquidity and cash flows and liability matching. On balance, we believe that all foreign currency exposures in the Reference Portfolio should be fully hedged to the NZD. Further analysis supporting our recommendation can be found in Appendix 3.

Representation

In the 2010 Reference Portfolio review, we considered all investable forms of asset class exposures as the starting point for constructing the Reference Portfolio and sought to represent them at their global capitalisation weights, provided there were liquid vehicles for doing so. We decided that Global Listed Property was sufficiently representative of investable Unlisted Property and, as a result, allocated 5% to Global Listed Property in the 2010 Reference Portfolio.

In this review, our starting point is not the full investable market (including unlisted assets). Rather, we adhere to the simple and low-cost design principle and start with the listed/liquid universe. As a result we no longer recommend a separate allocation to Global Listed Property in the Reference Portfolio.

Another representation issue that we have considered in the 2015 Reference Portfolio review is the lack of benchmark indices that are constructed to reflect full market capitalisation. Most benchmark indices use free-float adjustments in their index construction methodology. Our starting point is full market capitalisation representation. When we use these standard indices to implement the Reference Portfolio, we are trading off full representation and investability.

A full market capitalisation index is more complete while a free-float index is more investable. Pragmatic considerations will dictate how we navigate between completeness and investability in constructing the Reference Portfolio.

The proportions of developed market (DM) and emerging market (EM) in global equities is one key area where full market capitalisation weights can materially differ from free-float weights. To get us closer to full market capitalisation weights for the DM and EM segments of the equity market, we continue to use the free-float equity indices, but we set allocations to each based on current full market capitalization weights. In other words, to address the issue that EM is under-represented in free-float indices, we increase the allocation to EM by about 3% in the Reference Portfolio to better reflect the current full market capitalisation weight of EM. We recognise that this is an approximation to get to full market capitalisation. Our approach reflects a preference for pragmatism and operational simplicity.

A third representation issue to consider is the weight to NZ equities in the Reference Portfolio. The Fund operates with a ministerial directive that "… opportunities that would enable the Guardians to increase the allocation of New Zealand assets in the Fund should be appropriately identified and considered by the Guardians." In deciding a "fit for purpose" passive Reference Portfolio, this directive must be weighed against the principle of diversification and the liquidity constraints associated with the Fund being a sizable participant in NZ capital markets. On balance, and as was the case in 2010, a 5% exposure to NZ equities is seen to be appropriate for the Reference Portfolio. We should also note that the active investments in the Fund's actual portfolio have typically resulted in an aggregate exposure to NZ which is significantly greater than 5%.

Appendix 4 details the issues around full-market capitalisation in the Reference Portfolio, and sets out the options that we have considered in addressing the trade-off between completeness and investability. Appendix 5 reviews the arguments which support increasing or decreasing the exposure to NZ equities.

Inflation Risk

Investors should be concerned about inflation risk and we are not an exception to this general rule. We are concerned about NZ inflation risk. However, we would be unable to meet our objective to maximise returns by holding a great deal of NZ inflation-linked bonds. On the other hand, we do have a 20% allocation to fixed income assets in the Reference Portfolio and we need to consider whether our fixed income allocation should be exposed to just real or nominal interest rates.

If we were highly averse to NZ inflation risk, and if inflation hedging instruments were available in sufficient quantities, we could choose to pay for NZ inflation risk protection. However, long-dated NZ inflation linked bonds do not meet the 'simple' and 'low cost' Reference Portfolio design principles. NZ inflation linked bonds issued by the NZ Government are illiquid and the amount available is small relative to the size of the Fund. While global inflation-link products are available, they do not generally provide a good hedge to NZ inflation risk.

We note that even though our investment decisions are separate from the NZ Government's, purchasing long-dated inflation-linked bonds entirely issued by the Government does not address at all the issue of inflation hedging from the whole-of-Government perspective.

Choice of Benchmark Indices

NZSF's Reference Portfolio is an implementable portfolio. Once benchmark indices are assigned to the asset classes of the Reference Portfolio, we implement the allocations via physical and/or synthetic index portfolios. Therefore, it is important that we take implementation considerations into account when multiple indices are available for benchmarking. We outline five desirable characteristics that help guide our choice of benchmark indices for the Reference Portfolio:

Desirable characteristics of a benchmark index

Characteristic	Description
Objective selection criteria	Published rules and subject to a transparent governance structure.
Completeness	Should reflect the complete investable universe and should not selectively exclude assets based on some subjective criteria
Replicability	An investor should be able to closely replicate the index performance, e.g. if the index is calculated using gross dividends but investors must pay withholding tax, any investor would have difficulty replicating the index returns.
Investability	An investor can readily trade the constituent stocks with minimum market impact and transaction costs.
Acceptance by investors	Well recognised and widely used and that derivatives based on the index are traded in liquid markets.

Based on the characteristics outlined above, the benchmark indices shown below are chosen for asset classes in the Reference Portfolio.

Benchmark indices

Asset class	Proposed index
DM Equities	MSCI World Investable Market Index hedged to NZD
EM Equities	MSCI Emerging Market Investable Market Index hedged to NZD
NZ Equities	NZX 50 Gross Index
Global Fixed Interest	Barclays Capital Global Aggregate Index hedged to NZD

For pragmatic reasons, we have also applied a materiality threshold to exclude the smaller segments in the Global Fixed Income benchmark such as inflation-linked bonds, high yield debt and EM local currency debt. The associated fees and operational costs (both internal and external) of implementing small exposures outweigh the benefits of their inclusion.

A broader discussion on issues related to index choice is covered in Appendix 6.

Summary

NZSF has undertaken its first 5-year review of the Fund's Reference Portfolio. We have outlined our reference portfolio approach and its design principles, changes that the Board has made to the composition of the Reference Portfolio and key considerations in making the final decision. These considerations include the currency hedging decision, tradeoff between investability and full market capitalisation representation, inflation risk hedging, and the choice of benchmark indices.

Appendix 7 sets out the details of our capital market assumptions and Appendix 8 the results from our simulation analysis; this analysis supported the final decision. Appendix 9 provides a description of the economic scenarios that we incorporated into the simulation and examines the sensitivity of simulation results to alternative assumptions, including risk and return parameters, choice of hedge ratio and timing of Crown contributions.

Appendix 1: How has the Reference Portfolio performed against expectations?

The figures below show: 1) the performance of the 2010 Reference Portfolio against our performance expectations, and 2) the distribution we used in the 2010 reference portfolio review to depict expected Reference Portfolio returns, along with the last 11 years of historic benchmark returns.

Figure 1: Performance of the 2010 Reference Portfolio

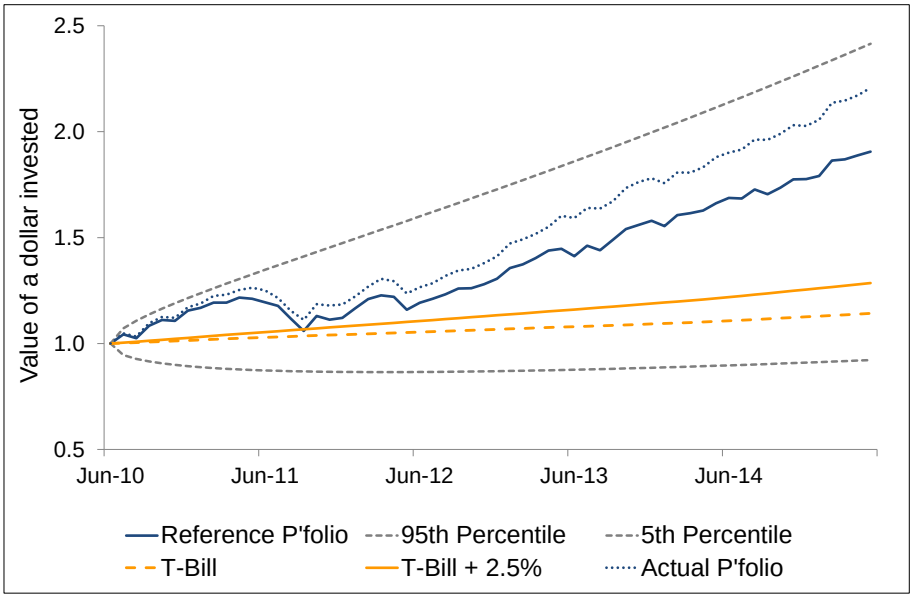
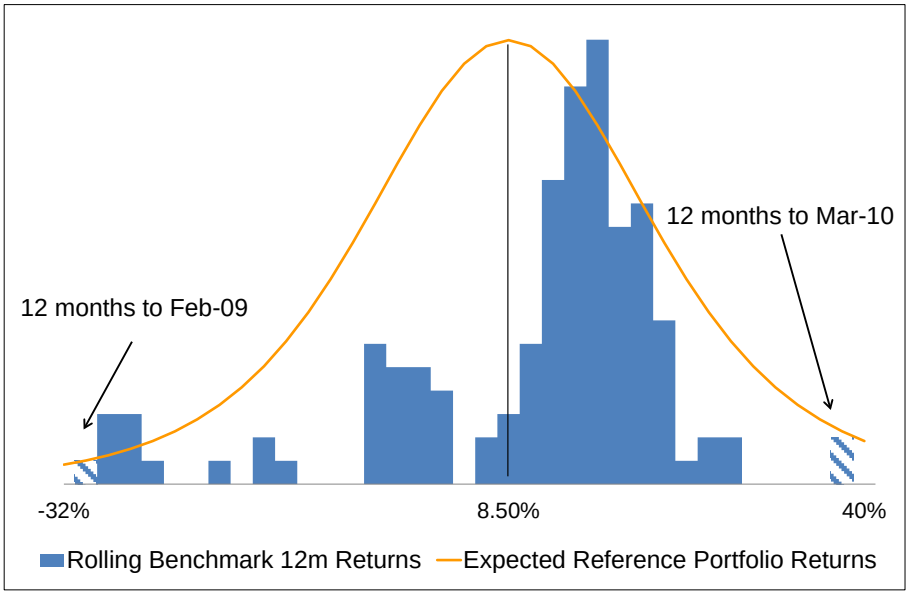


Figure 2: Expected and actual benchmark returns



The Fund has seen high returns over recent years, in part due to the performance of the Reference Portfolio and in part due to value-adding investments in the actual portfolio (as shown in Figure 1). The five year performance of the Reference Portfolio has been around

14% p.a., considerably above our long term expectations in 2010 of 8.5%[1], and reflecting a favourable market for growth assets – the five year return is in the 85th percentile of our expectations. Along with these abnormally good periods, we also expect that there will be periods of abnormally low returns and we remain focused on the Fund's returns *over the long-term*.

[1] Our long term expectation in 2015 is 7.7%; see Appendix 2.

Appendix 2: Long-run performance expectations

In 2015 our long run expectation of returns for the reference portfolio is 7.7% p.a., comprising a risk-free rate of 5% (down from 6% in 2010) and a return of 2.7% (from 2.5% in 2010) for the market risk in the Reference Portfolio versus this risk-free rate, as set out below.

Figure 1: 2015 long-run performance expectations

Component of Return	Risk-Free Rate		Excess Return After Costs		Reward for Value-Adding Activities		
	5%	+	2.7% (which is the reward for taking market risk above cash or the Risk-Free Rate)	+	1.0%	=	8.7%
Explanation	Our estimate of the equilibrium return on 90-day Treasury Bills.		We define the reward for market risk as the margin between the risk-free rate and the return that would be generated on the Reference Portfolio (after assumed costs of 0.25%). Although the estimates of market risk vary over time, we provide the equilibrium, or long term, expectation of the rewards for market risk on the Reference Portfolio. Our estimate of the reward for market risk has a very wide range over a one-year horizon, although this range tightens over longer horizons.		Our estimate of the return from the investment activities we undertake to add value.		The mid-point of our estimated range for the actual portfolio return is 8.7%.

The lower expectation of the long-run NZ risk-free rate largely reflects a lower growth forecast for NZ by organisations such as the OECD and UN. Also 5% interest rates are in line with the revised equilibrium rate expectations of other groups (like the Reserve Bank of NZ), and is consistent with the pricing of long-term bonds in NZ. There is more on this change in Appendix 7.

The higher expectation of excess returns after costs results from the removal of some rounding in 2010 (0.09%), slightly higher exposure to riskier emerging markets (0.06%), and a slightly lower estimate of the costs of running the reference portfolio (0.05%); this lower cost results from a general movement down in passive management fees and our expectation that this will be maintained going forward.

We also estimate a 1.0% reward for investments in the actual portfolio that are designed to be value-adding to the Reference Portfolio. This estimate is unchanged.

Appendix 3: Currency hedging

In this appendix we review the NZ dollar (NZD) as the numeraire currency of the Fund, discuss issues in choosing a hedge ratio, and consider whether we should only hedge developed market (DM) equities, given the NZD will not have an interest rate advantage against some emerging market (EM) currencies.

A: What is the numeraire currency?

The Fund has no explicit liabilities. However, the Fund is a NZD fund with its ultimate success measured in the NZD returns it generates.

We are also concerned with the NZD purchasing power. This could be a reason to consider having foreign currency exposure in the Fund and a basket of currencies as the numeraire. However, long-run evidence suggests that NZ T-bills earn a return above realised inflation. Thus, we view setting the NZD as numeraire currency, which effectively puts global risk premia on top of NZ Treasury bills, as sufficient to ensure long-run protection against unanticipated NZ inflation.

One potential exception is if the NZ price level is subject to sudden, large jumps, as might occur following a massive permanent depreciation in the New Zealand dollar. Sensitivity analysis in Appendix 9 examines alternative hedging ratios in the context of a number of scenarios where the NZD is subject to large and long-lasting depreciations, resulting in higher NZ inflation. In general, we regard seeking insurance against specific and rare events as better considered as an active strategy in the actual portfolio, rather than in the Reference Portfolio which is an equilibrium concept.

B: What currency hedge ratio?

Choosing a numeraire does not necessarily imply that a Fund should fully hedge to that numeraire. Considerations in determining a currency hedge ratio include:

- the risk and return impact of a deviation from the numeraire currency, and risk tolerance;
- regret risk; and
- liquidity use and implementation issues.

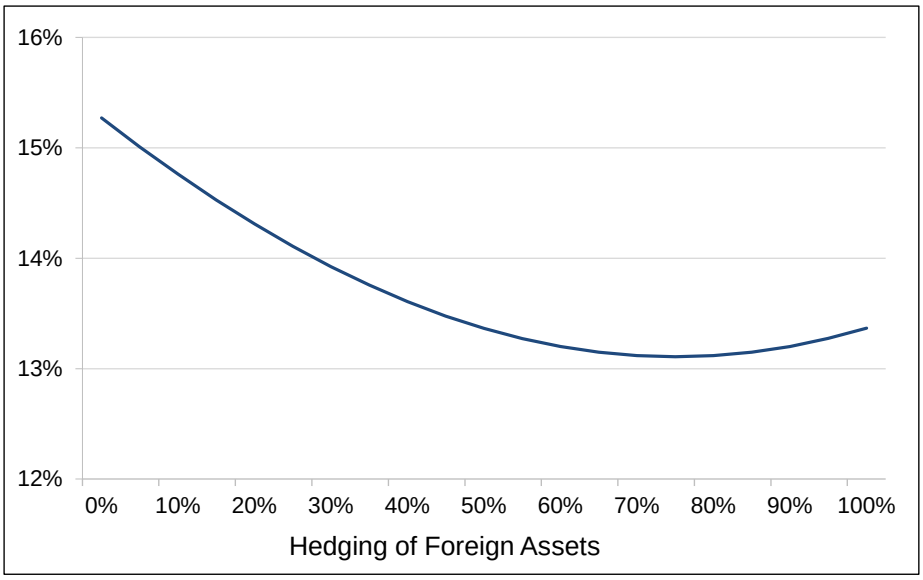
Risk and return considerations

Figure 1 shows the volatility of the base case candidate portfolio (i.e. 80% growth and 20% fixed interest) for different degrees of currency hedging using our equilibrium risk assumptions (i.e. ignoring any currency return assumptions).

Figure 1 demonstrates that there is small risk reduction benefit to introducing foreign currency into the portfolio for amounts less than 25% (i.e. hedging of 75%). For amounts greater than 25%, the risk of the portfolio is worsened. The risk reduction however, is very slight (about a 0.2% reduction in volatility) and there is little to distinguish the risk reduction for hedge ratios from 50% to 100%.

When we bring our return assumptions into the picture, our assumed 80bp risk premium in favour of the NZD leads the optimal choice of a 100% hedge ratio. We believe that a currency risk premium is compensation for relative systematic financial vulnerability. We have assumed that the NZD risk premium reflects NZ's large net foreign debt and its narrow, commodity-oriented export base.

Figure 1: Reference Portfolio risk and NZD Hedging



An alternative thesis is that the NZD risk premium is in part compensation for the possibility of large but rare disasters befalling the global economy (during which the NZD would typically depreciate versus a global basket). Appendix 9 discusses such research in the broader context of the total impact on the Reference Portfolio.

Other considerations

Some funds will temper their strategic hedge ratio after considering the proportion of the fund held in risky assets, the proportion held offshore, the potential for regret risk, the need for an allowance for tactical deviations, and/or concern regarding the costs and cashflow impact.

- A fund that is predominantly invested in non-numeraire denominated assets or in lower risk assets, such as fixed interest, will typically have higher hedge ratios. This is because currency volatility could have a larger impact on returns in some cases.
- Some funds will choose to minimise regret (and opt for a 50% hedge ratio) where they feel there are many states of the world that could eventuate and are concerned about "being wrong" after taking an extreme position (i.e. being fully hedged or fully unhedged).
- Some funds will choose slightly lower than fully hedged or slightly higher than unhedged to given them a range within which to tilt the hedge ratio, because of perceived or actual limits to hedging at a maximum of 100% and a minimum of 0%.
- Some funds will not hedge, or at least lower the hedge ratio, because of concerns regarding the costs, cashflow management, counterparty credit management and/or liquidity impact of currency hedging.

We are less concerned about these issues. Risk of regret does not feature in best practice portfolio construction for institutional investors. We also do not see an issue with tilting currencies around a fully hedged or unhedged benchmark. Currency tilts are part of the Fund's tilting programme with its own risk budgets and prudential limits. In addition, we have an explicit consideration of overall liquidity risk through the Fund's liquidity management framework.

While there are important administrative considerations in currency hedging (e.g. managing cash flows arising from gains and losses in currency hedges and counterparty credit exposure), we do not consider these to be an undue burden. There is no liquidity impact when rolling out-of-the-money currency hedges for the Reference Portfolio given that Reference Portfolio assets, being highly liquid, can be readily bought or sold to match any cashflow requirements. Currency hedging management practices are well established in currency hedged index funds and these types of funds are common in the industry.

The only remaining consideration is the costs of hedging. We have estimated the cost of hedging the Reference Portfolio as part of an analysis of the costs of running the Reference Portfolio, and we do not believe it to be prohibitive in the context of implementing a passive portfolio.

C: Only hedging currencies less risky than NZD

Of course, currency risk premia are a relative concept; we are long one currency risk premium and short another currency risk premium. So what about those currencies that have a higher currency risk premium than the NZD? We have, in our previous strategic asset allocation and Reference Portfolio reviews, treated the foreign currencies as a single block. We could consider two currency blocks instead: those currencies that are less risky than the NZD and those that are more risky. For this latter block, the risk and return considerations may suggest a benchmark that is less than fully hedged.

There are four considerations that argue for full hedging, including these riskier currencies:

1) We do not have high confidence in the estimates of currency risk premia in equilibrium, which is why we present our hedging analysis with and without a currency risk premium assumption.
2) As a percentage of the total basket, the exposure to currencies that are more risky than NZD is small (5.5%, with the largest weights being the South African Rand, the Brazilian Real and the Indian Rupee).
3) We are constrained by the investable return indices that we can use if we were to not hedge just a subset of currencies. Country level indices are available, but combining these into an overall performance index is operationally complex and expensive to achieve, particularly when using derivatives (there is more on operational complexity in Appendix 4).
4) We could use a market categorisation of the countries in the all world index into DM and EM. We argue in this paper (see Appendix 6) that this is a useful categorisation for the purposes of improving completeness. The NZD risk premium is approximately 80bp in favour of NZD against DM currencies but there is only a 5bp in favour of EM currencies against NZD. This 5bp premium does not justify leaving EM currencies unhedged; the risk premium is not as high as we might have expected because of the high weights to low-currency-risk countries in the emerging index (e.g. Korea, Taiwan). At the aggregate level, the answer would still be to fully hedge the EM index.

Our conclusion is that the Reference Portfolio should continue to be 100% hedged.

Appendix 4: Reflecting full-market-capitalisation

A: Biases from free float methodology

Most investable indices use free-float adjustments in the index construction methodology, which gives rise to a trade-off between the desire for indices to be investable and the desire for them to be complete.[2] Index providers impose some minimum liquidity requirements before a stock is admitted to the index. Corporate and large block holdings that are deemed to be strategic (e.g. blocks held by governments) are also excluded from index weight calculations.

The full capitalisation of a company represents its market value at any given point in time which, for reason of completeness, should be included in index calculations. However, strategic shareholders who are holding large blocks of shares might genuinely have no intention to sell their shares and these holdings are effectively not available to other investors. Therefore, under the investability criterion, they should be excluded in index calculations.

A full-market-cap index is more complete while a free-float index is more investable. Both are proxies for the unobservable true market portfolio and there is no strong reason to believe that one is superior to the other. Pragmatic considerations will dictate how we navigate between completeness and investability in constructing the Reference Portfolio.

The proportions of developed market (DM) and emerging market (EM) in global equities is one main area where full-market-cap weights can materially differ from free-float weights. For instance, EM equities currently make up about 10% of the MSCI free-float index while DM equities make up the other 90%. However, when measured using full-market-cap weights, EM equities account for around 16%, or 6% more than its free-float adjusted weight.[3] Other things being equal (i.e. if investability and ease of implementation were the same), we would prefer a full-market-cap index to a free-float index given that a full-market-index is more representative of true market values in the equities universe.

B: Options for addressing the biases

Use of full-market-cap indices presents significant implementation challenges. However, there are options that we can consider that will move us closer to the full-market-cap portfolio:

- Option 1 is to change all equity indices from free-float to full-market-cap. Full-market-cap indices are not widely used by investors and therefore will be more costly to adopt. Explicit costs include higher fees paid to managers and index providers while implicit costs involve trading in less liquid derivatives markets and/or incurring higher tracking errors if liquid proxies are used. On the other hand, this option will allow us to achieve full-market-cap exposure at the security level.
- Option 2 is to use country level free-float indices to match full-market-cap weights at the country level. Country level free-float indices are widely accepted by investors and therefore additional costs involved in physical implementation would be lower. However, the operational burden for synthetic implementation will be high since we need to trade and rebalance as many as 46 country level swaps/futures. This option will allow us to achieve full-market-cap exposure at the country level.

[2] There is more on the desirable characteristics of benchmark indices in Appendix 6.

[3] The 6% difference between free-float and full market capitalisation is based on our own calculation using MSCI free float information and estimates provided in a discussion note from Norges Bank (*Free Float Adjustments in Global Equity Portfolios, Norges Bank Investment Management, Discussion Note 05/2014, 10/09/2014*).

- Option 3 is to use DM and EM free-float indices to match full-market-cap weights at the broad market level. The additional costs involved in both physical and synthetic implementation would be minimal apart from increased rebalancing across DM and EM managers/markets. This option will allow us to achieve full-market-cap exposure at the broad market (DM and EM) level.
- Option 4 is to keep DM and EM as separate building blocks in the Reference Portfolio and maintain fixed-weight allocations to each based on full-market-cap weights. This option has no additional operational impact on both physical and synthetic implementation, but it only allows us to achieve an approximate exposure to full-market-cap at the broad market level in between Reference Portfolio reviews. However, compared to our current free-float approach, it does provide a better representation of the current full-market-cap weight of broad DM and EM markets in the Reference Portfolio.

We should note that the representativeness characteristics that we are seeking relate to listed market capitalisation rather than unlisted market or economic (such as gross domestic product) representation. With the full-market-cap approach, we are still investing in a passive portfolio based purely on market-determined capitalisation weights rather than free-float-adjusted weights.

As outlined above, there is a trade-off between the varying degrees of full-market-cap completeness and implementation costs. Our preference lies towards pragmatism and operational simplicity. Therefore, in this Reference Portfolio review, we recommend Option 4: to treat DM and EM as separate building blocks in the Reference Portfolio and maintain fixed weight allocations to each that are approximately based on full-market-cap weights. This provides the most straightforward way to address the completeness issue without imposing any additional operational burden on the Fund.

To summarise, we recommend that we continue the use of free-float indices and upweight the EM equities component of the Reference Portfolio to better reflect full market capitalisation.

C: Allocation of EM versus DM

Using free-float weights, EM represents 10% of the equities universe. Using full-market cap weights, EM represents 16% of the equities universe. The table below shows the equivalent allocations in terms of Reference Portfolio weights assuming an 80/20 growth and income mix (with a fixed 5% allocation to NZ equities).

Table 1: Allocations to EM and DM equities

Asset class	Free-float (10% EM in equities universe)	Recommended	Full market cap (16% EM in equities universe)
DM equities	68%	65%	63%
EM equities	7%	10%	12%
Total global equities	**75%**	**75%**	**75%**

We believe that the EM equities allocation should be 10% after the following considerations:

- **Adjustments for company cross-shareholdings.** There is some uncertainty around the true full market capitalisation weight of EM in the equities universe. Our best estimate is an EM weight of 16% which is not adjusted for listed company cross-

shareholdings. Listed company cross-shareholdings should be removed as these holdings inflate the market capitalisation of companies.

- **Aggregate EM allocation to deal with stock level representation.** The completeness that we are seeking is at the stock level. Ideally, we should account for the full market capitalisation of each stock and invest accordingly. However, for operational and costs reasons discussed earlier, we correct for this by adjusting the total EM equities weight using free-float indices, which introduces other forms of biases (e.g at country and sectors levels) under this approach. Despite this, we believe that our pragmatic approach would still help address the representation issue at the broad level.
- **Pragmatism.** Given that there will always be some degree of uncertainty in deciding the current level of full-market-cap, and that our proposed approach to addressing the issue is only meant to be an approximate solution, we believe that a pragmatic approach is to round the EM equities allocation to 10% rather than having to work out the exact weight which fluctuates over time.

We expect the split between DM and EM in the Reference Portfolio to be reset closer to their respective full-market-cap weights at the time of the next Reference Portfolio review, or when there are material changes to index constituents or free-float percentages in the interim.[4] We also suggest that interim changes would only be made when the estimated EM full-market-cap weight differs from 10% by a ±5% materiality threshold. In such a case, we would approach the Board recommending a change to Reference Portfolio weights.

[4] An example of a change that would trigger a review is if China A shares were to enter the MSCI universe.

Appendix 5: NZ equities overweight

Our starting position regarding a weight to NZ equities within the growth portion of the Reference Portfolio, is zero, given its less-than-0.1% weight in the all world equity index.

Prior to the introduction of the Reference Portfolio in 2010, arguments for a NZ equities overweight have been mainly based on the perceived availability of significant alpha in the NZ equities market, and while we agree with the potential for alpha in the NZ equities market (and have our NZ equities allocation actively managed), this is an actual portfolio, not a Reference Portfolio, consideration.

Despite this, we argued in 2010 that a 5% overweight to NZ equities should be included in the Reference Portfolio given that this weight reflects an appropriate balance between the Ministerial directive to "identify and consider" NZ investments and our mandate to maximize returns:

- The Ministerial directive (delivered under Section 64 of our Act) states that the Guardians must identify and consider NZ investments, subject to remaining in accordance with Section 58 of our Act.
- Under Section 58 of our Act, we are required to maximise returns without undue risk. Under our assumptions, NZ equities have a 30bp lower expected return than global equities, adjusting for risk. However, there is considerable uncertainty around the forecasts for NZ equity returns, and the overall risk and return profiles of the Reference Portfolio with and without the allocation to NZ equities are largely indistinguishable, particularly for small allocations to NZ equities.
- An allocation of 5% reflects the minimum allocation to any asset class to make its contribution to the Reference Portfolio meaningful.

In 2015, we continue to support this assessment and an overweight to NZ equities. There are some arguments that suggest a lower weight than 5%, but again we believe these are actual portfolio considerations:

- Analysis has focused on the capacity constraints in the NZ market for active management of NZ equities. We are currently over 2% and at similar levels to those at the time of the last Reference Portfolio review. However, the Reference Portfolio considers only passive holdings and we do not believe that we are near to any constraint on passive holdings.
- We have a higher weight to NZ assets in the actual portfolio due to our value-add NZ investments, and an increased exposure to NZ specific risk. However, exposure to NZ specific risk can be managed within the actual portfolio and need not impact on the composition of the Reference Portfolio.

In summary, we believe that the Reference Portfolio should continue to have a 5% overweight to NZ equities because it is consistent with the Ministerial directive to identify and consider NZ investments.

Appendix 6: Choosing a benchmark index

A: Index choice considerations

A benchmark index establishes a performance standard against which the effects of active management can be measured. These effects include asset class strategy, manager and stock selection, currency management, and timing and implementation decisions. Therefore, the selection of benchmark indices is an important part of the Reference Portfolio construction.

A standard benchmark index provides a broad representation of the universe of securities from which an investor could invest. It also provides a low cost and investable means for an investor seeking a passive and diversified market exposure.

When multiple indices are available for benchmarking, we believe that there are five desirable characteristics, listed in Table 1 below, that we should consider in deciding on their merits. The list is by no means exhaustive and we may place different emphasis on each characteristic in our choice of index.

Table 1: Desirable characteristics of benchmark indices

Characteristic	Description
Objective selection criteria	It is critical that a benchmark index has objective and well defined rules. The rules must be published and subject to a transparent governance structure. This ensures that neither the index provider nor any other market participants are able to manipulate the index values to their own advantage.
Completeness	A benchmark index should include all securities that are accessible to market participants. It should be represent the complete investable universe and should not selectively exclude assets based on some subjective criteria (with the exception of special purpose indices such as ESG based equity indices). An index portfolio which is more representative of the full universe of investable assets is more diversified than one that has a narrower coverage. A more complete index also better replicates the passive strategy of holding all available assets, which is a desirable property for an index that is often used as a performance benchmark for active strategies.
Replicability	The returns reported for a benchmark index should be replicable. For example, if the index is calculated using gross dividends but investors must pay withholding tax, any investor would have difficulty replicating the index returns and struggle to implement an index portfolio as a passive strategy.
Investability	An index should be investable to the extent that one can readily trade the constituent stocks with minimum market impact and transaction costs. This is important especially when index construction generally ignores any transaction cost. For example, if an index is made up of a large number of stocks in a country that are not accessible to foreign investors, investors will struggle to replicate the benchmark return. Similar issues exist for highly illiquid stocks.

Characteristic	Description
Acceptance by investors	A benchmark index should be well recognised and widely accepted for use by market participants. The advantages for an institutional investor to benchmark to a widely accepted index include crossing opportunities, program trades, and the ability to use derivatives. While popular indices could suffer from index reconstitution (inclusion and deletion) effects[5], we expect these effects to be limited due to actions of hedge funds and other investors who try to trade ahead of time to profit from the impending changes.

It is not generally the case that we can find a benchmark index with all the desirable characteristics listed above. Some of the characteristics can be at variance with each other. For example, an index with complete coverage of the universe would include the smallest and most illiquid stocks that are costly to trade, while these stocks might be ruled out under the investability criterion. We need to consider such trade-offs in choosing a benchmark index.

Index providers face similar considerations. A prime example is the use of free-float adjustments in the index construction methodology. The full capitalisation of a company represents its market value at any given point in time which, under the representativeness criterion, should be included in the index calculation. However, there are many companies with shareholders who own significant blocks of shares and who are expressly long-term or strategic investors. These shareholders could be the original owners or government entities who currently have no intention to sell their shares. These shares are effectively not investable by other investors and therefore, under the investability criterion, they are excluded in the free-float index construction methodology. There is more on the free-float versus full-market cap issue in Appendix 4.

B: Indices for asset classes

Based on the above considerations we propose the following indices for the Reference Portfolio:

Table 2: Benchmark indices

Asset class	2010 Index	Proposed Index
DM equities	MSCI All Country World Investable Market Index hedged to NZD	MSCI World Investable Market Index hedged to NZD
EM equities		MSCI Emerging Market Investable Market Index hedged to NZD
NZ equities	Customised NZX 50 Capped Index	NZX 50 Gross Index
Global fixed interest	Customised Barclays index hedged to NZD: • Barclays Capital Global Aggregate • High Yield Debt • EM Local Currency Government • Inflation Indexed Bonds,	Barclays Capital Global Aggregate Index hedged to NZD

[5] These effects consist of upward price pressure on stocks chosen for inclusion in an index and downward price pressure on stocks taken out of the index on the day of index reconstitution.

1.1 We note the following proposed changes from the indices employed in the 2010 Reference Portfolio and reasons for these changes. A full review of available indices can be found in Annex E of the *2010 Reference Portfolio Review*.

- **Implementability**
  - The separation of DM and EM equities is best implemented using free float indices. As discussed in Appendix 4, free float indices are more widely used and easier to implement in physical and synthetic form and cheaper to gain exposure.
  - The 2010 Reference Portfolio uses the NZX 50 Capped custom index. The index is a custom index that limits any single stock to no more than 15% of the index. We believe that the NZX 50 Gross Index (i.e. the non-capped version) should be adopted for the following reasons: (i) it is less capacity constrained than the capped index since the allocation to any capped stocks would need to be re-allocated to potentially less liquid stocks, particularly as the Fund is expected to grow and our allocation to NZ equities becomes a larger proportion of the NZ equity market; and (ii) stock concentration issues are best dealt with by altering the NZ equities weight. Furthermore, since about June 2009, no stock has been greater than 15% of the index and our existing external managers already use the NZX 50 Gross Index as their benchmark.
- **Materiality**
  - The 2010 fixed interest index is customised using the Barclays Global Aggregate and other substantially smaller fixed interest sectors, such as inflation linked bonds, high yield debt and emerging market local currency debt. However, we believe a materiality threshold should be applied to these smaller segments given the associated fees and operational costs, which are both internal and external, of implementing small exposures. As a result we recommend that they are dropped from the Reference Portfolio.
    - Firstly, the fixed interest allocation in the Reference Portfolio is only 20% of the fund value. Accounting for the assets we sell when we bring private market assets into the actual portfolio, the size of any fixed interest customisation is reduced even further.
    - Secondly, the “actual portfolio” size of any customisation needs to be sufficiently large to justify the managerial burden and cost of engaging a dedicated physical manager or utilising specific derivatives (e.g. swaps) to implement the customised fixed interest sector.
  - We intend to continue to monitor the materiality of these smaller segments over time, given inevitable changes in the size of the Fund and the cost of implementing these asset classes.

Appendix 7: Risk and return methodology

A: Background

Equilibrium assumptions

Risk and expected return are the two most important characteristics of any investment portfolio. While realised risk and return of different asset classes fluctuate through time and can fluctuate widely at times, they are more stable when measured across longer time horizons. From the perspective of long-term investors, it is the *long-run* portfolio risk and expected return characteristics that are of most relevance. The equilibrium assumptions are estimates of these long-run risk and expected return characteristics that we use to help inform the choice of the Reference Portfolio.

What do we mean by 'equilibrium'?

Equilibrium can have different meaning in different contexts. In economics, equilibrium refers to the state when supply meets demand in any market. In the context of risk and expected return assumptions, equilibrium is used to denote a long-run state of affairs in capital markets, although this begs the question of how long 'long-run' is.

There is little value to specify a time horizon (e.g. 20-year or 30-year) for our equilibrium assumptions. First, long-run risk and return estimates are subject to considerable uncertainly and therefore the confidence we can have in anchoring those estimates to any specific time horizon would be even lower. Second, time horizon specific risk and return estimates often require the use of valuation and/or yield curve models that dictate how these metrics evolve over time. Even though we do employ some of these approaches to derive horizon specific return estimates in managing the actual portfolio, they often require more subjective inputs (e.g. the speed of mean reversion) and are probably less appropriate for setting equilibrium assumptions. Therefore, we use equilibrium to refer to the long-run and leave the exact time horizon intentionally vague.

When would the equilibrium assumptions change?

Equilibrium risk and return assumptions are not theoretical constructs and they are to a large extent influenced by historical data. It is the long history of data we have in traditional asset classes that give us a good handle on their risk and return characteristics. On the other hand, economies and financial markets have undergone significant changes and data from the more distant past may no longer provide a relevant guide for the future. Econometricians are routinely on the lookout for regime or structural changes and adjust parameters used in their models accordingly to achieve better forecasts.

We take a similar approach in setting our equilibrium assumptions. We start with historical data and survey existing literature to look for suggestions of any potential regime changes. If we are convinced that the current regime is different from the past, we adjust historical estimates to reflect the regime change. We also compare our own estimates against surveys of equilibrium assumptions used by peer funds and their consultants. We repeat this process periodically with new information on hand to decide if any revisions to current equilibrium assumptions are warranted.

Current equilibrium assumptions for assets in the Reference Portfolio

The current risk and return assumptions were last reviewed in 2013 and are shown in Table 1.

Table 1: Current risk & return assumptions for Reference Portfolio assets

Correlations								
All global assets are assumed to be fully NZD hedged	DM large cap	DM small cap	EM equities	Global listed property	NZ equities	Global sovereign bonds	Global credit spread return	NZ Treasury bills
DM large cap	1.0							
DM small cap	0.8	1.0						
EM equities	0.7	0.6	1.0					
Global listed prop.	0.8	0.7	0.6	1.0				
NZ equities	0.7	0.6	0.5	0.6	1.0			
Global sov. bonds	0.1	0.1	0.1	0.1	0.1	1.0		
Global credit spread	0.6	0.5	0.4	0.5	0.4	0.1	1.0	
NZ Treasury bills	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

	Volatility (p.a.)	Expected Return (p.a.)
DM large cap	16%	6.0 + 3.5 = 9.5%
DM small cap	20%	6.0 + 3.9 = 9.9%
EM equities	26%	6.0 + 4.4 = 10.4%
Global listed property	16%	6.0 + 2.8 = 8.8%
NZ equities	18%	6.0 + 2.5= 8.5%
Global sovereign bonds	4.5%	6.0 + 0.4 = 6.4%
Global credit spread	3.5%	0.5% (on overlay only)
NZ Treasury bills	-	6.0%
Reference Portfolio	*13.2%*	*6.0 + 2.9 = 8.9%*

DM = Developed market; EM = Emerging market, NZ = New Zealand, NZD = NZ dollar

B: Review of Reference Portfolio assumptions

Overview

In setting the risk and return equilibrium assumptions for Reference Portfolio assets, we start with the risk assumptions which involve estimating the long-term volatility of each asset and correlations among assets. The volatility estimates are primarily guided, but not entirely driven, by historical data. For correlations, we first estimate each asset's sensitivity to global equities and global bonds. With these estimates (also known as 'factor loadings') and the assumed volatilities of and correlation between the equities and bonds 'factors', we can derive the implied pairwise correlations among assets.

The return assumptions are based on the risk assumptions and the classical capital asset pricing model. We use the assumed NZ cash rate as the risk-free rate and the global investable market as a proxy for the unobservable market portfolio.

Volatility assumptions

The approach to establishing the volatility assumptions is outlined in section 4, Annex C of the *2010 Reference Portfolio Review*. We have used the same methodology and updated the historical data series to 2015. The results are shown in the table below.

Table 2: Long-run volatility assumptions for the Reference Portfolio

Index	Historical volatility in the July 2013 review	Historical volatility updated to Dec 2014	Volatility assumptions in the Reference Portfolio
MSCI World Index (NZD hedged)	14.4%	14.1%	16.0%
MSCI Global Small Cap Index (local currency)	18.4%	17.7%	20.0%
MSCI Emerging Markets Free Index (local currency)	25.2%	24.5%	26.0%
UBS GREI Index (updated with EPRA/NAREIT)	15.2%	15.0%	16.0%
NZ Equities	15.6%	15.6%	18.0%
Citigroup World Government Bond Index (NZD hedged) 7-10 year maturities	4.0%	4.1%	4.5%
Barclays Capital US Investment Grade Credit Index	5.5%	5.4%	3.5%

Despite the relatively low volatilities experienced in financial markets in the past two years, the updated historical volatilities do not differ much from those in the 2013 assumptions review. This is not surprising given the relatively short time period since the last review.

We do not believe there are any significant structural changes in capital markets since 2013 that warrant changes to the current equilibrium volatility estimates of the Reference Portfolio.

Correlation assumptions

Observed correlations among asset classes typically fluctuate around a wide range of values over time. The noise in the data is such that we have relied more on judgment rather than historical data in setting the correlation assumptions.

We use a factor-based approach to estimating correlations. Under this approach, we estimate each asset's sensitivity to global equities and global bonds, and derive the implied pairwise correlations among assets based on these factor loadings. For example, when the returns on asset A and asset B are driven by the global equities factor only, fluctuations in global equities returns will likely drive the returns on both assets A and B in the same direction. As such, there will be an implied correlation between the returns of the two assets and hence there is no need for us to estimate the pairwise correlation among assets separately, once we have estimated their factor loadings.

We do not see any significant changes in capital markets since the 2013 review that warrant changes to the current equilibrium correlation estimates. The correlation assumptions shown in Table 1 above continue to be our best estimates of the equilibrium correlations among the assets in the Reference Portfolio.

Expected return assumptions

The expected return assumptions for Reference Portfolio assets are derived using the classical capital asset pricing model. In that model, the expected return on any asset is given by the risk-free rate plus a risk premium. The risk premium is calculated as the product of the systematic risk of the asset and the assumed expected return on the market portfolio.

Since the 2005 strategic asset allocation review, we have used the global investable market (GIM) as a proxy for the unobservable market portfolio. Many investors would, instead, use a standard index of global equities as the proxy for the market portfolio. Under their approach,

the systematic risk or beta of any asset would be estimated against the equity market index and therefore its expected return would be a function of this *equity beta* and the *equity market risk premium*.

The main difference between the GIM and the global equity index portfolio is that the GIM includes global bonds. Therefore, under our approach, the expected return of any asset will be a function of its systematic risk when measured against the GIM, which is a broader portfolio of equities and bonds. In this case, the expected return of the asset will be a function of this *GIM beta* and the *GIM market risk premium*.

The GIM approach is, in principle, more appealing since it allows both bond and equity assets to be priced based on their systematic risk contribution to the market portfolio containing both assets. In contrast, when an equity index is used as a proxy for the market portfolio, bonds are not part of the equity index portfolio and therefore they cannot be priced based on their systematic risk contribution to that market portfolio. As such, the risk premium for bonds will need to be determined separately and the resulting estimate might not be consistent with the risk and return relationship for other assets in the index portfolio.

On the other hand, there are drawbacks with the GIM approach when applied to produce long-term expected return estimates. The market capitalisation weights of bonds and equities change over time and the weights will affect the expected return estimates. Other things being equal, a higher (lower) market capitalisation weight for an asset will result in a higher (lower) expected return estimate. This is a feature of the approach which can be problematic at times when there are significant changes in the relative capitalisation weights of bonds and equities. For instance, based on this approach, after a share market crash the weight for equities drops substantially relative to bonds and the expected return estimate for equities will drop accordingly. If we happen to be reviewing our risk and return assumptions at that time and we hold the belief that markets will mean revert, a lower expected return estimate for equities (and a relatively higher expected return for bonds) may lead to an asset allocation decision that is contrary to what a long-term investor should do.

A better way to address this issue is through the use of a set of fixed weights that represent the long-run average weights for asset classes in the GIM. This is the approach we have taken this time with the intention that our long-run expected return estimates will not be driven by the market capitalisation weights at the time of future reviews. Table 3 contains the market capitalisation weights used in previous reviews and the average weights that we have chosen to use in this review. More information about the composition of the global investable market portfolio can be found in "The Global Multi-Asset Market Portfolio, 1959–2012".[6]

Table 3: Market capitalisation weights used/assumed for the GIM

Assets	Weights used in the 2010 review	Weights used in the 2013 review	Assumed long-run average weights used in 2015
DM large cap	41%	31.9%	40.0%
DM small cap	-	4.9%	5.0%
EM equities	5.0%	4.3%	5.0%
Global unlisted property	2.0%	1.3%	-
NZ equities	0.04%	0.03%	0.0%
Global bonds	51.0%	57.5%	50.0%
Global credit (spread)	25.0%	28.8%	25.0%

[6] Doeswijk R., T. Lam & L. Swinkels. "The Global Multi-Asset Market Portfolio,1959–2012", *Financial Analysts Journal*, 2014, v70, no. 2.

We should note that even under the GIM approach, our equity risk premium (ERP) assumption of 3.5% still provides the anchor for all other risk premium assumptions. For example, DM large cap has an estimated beta of 1.65 when measured against the GIM. We therefore set the risk premium for the GIM to be 2.1% (such that 1.65 * 2.1% = 3.5%). The risk premium for all other assets will then be given by $\beta_{i,GIM}$ x 2.1%, where $\beta_{i,GIM}$ is the beta of asset i measured in the context of the GIM.

The GIM beta and expected return estimates (rounded to one decimal) based on the new asset weight assumptions for the GIM are shown in Table 4 below. The risk premium estimates are the same (at the 1% decimal point level) as those in the 2013 review, with the exception of DM small cap which is 0.1% smaller (3.8% this time compared to 3.9% previously).

Table 4: GIM beta and implied risk premium

	Beta to Global Investable Market	Risk Premium
DM large cap	1.7	3.5%
DM small cap	1.8	3.8%
EM equities	2.1	4.4%
NZ equities	1.3	2.5%*
Global sovereign bonds	0.2	0.4%
Global credit spread	0.3	0.5%
Global Investable Market	1.0	2.1%

** Expected return for NZ equities is set to be 0.3% below what its beta would imply, given the estimated impact of the Fund's pre NZ-tax measure of return.*

NZ cash rate assumption

We believe that real returns on 90-day NZ Treasury bills (NZ T-bills) are likely to be lower in the future than have been in history so that a reduction in the cash rate assumption from 6.0% to 5.0% p.a. is warranted. The rationales for the change include:

- A 2013 Reserve Bank of New Zealand (RBNZ) speech directly addressed the question of whether the neutral rate was lower post the global financial crisis of 2008 (GFC). The RBNZ currently believes the neutral 90-day Bank Bill rate to be 4.5%, albeit with a "fairly wide confidence interval – perhaps 100 basis points or more".
- The RBNZ attributed decreases in the neutral rate primarily to a trend weakening in NZ's productivity growth and population growth, both of which contributed to a lower potential GDP growth rate and, in equilibrium, a lower neutral interest rate. The RBNZ also noted post GFC changes have raised the spread between the official cash rate (OCR) and retail interest rates, meaning that a lower OCR than in the past is now needed to achieve a target level of monetary conditions.
- Our most recent long-term growth forecasts, based on OECD and UN data, are for the NZ economy to grow at a lower rate than previously expected in the 2010 Reference Portfolio review. This implies that future equilibrium interest rates will be lower than observed in the past.

Summary

The risk and return assumptions used in this 2015 review are summarised in Table 5. The total expected return estimates are also lowered by 1% across the board this time, due to the 1% lower cash rate assumption.

Table 5: Risk & return assumptions for Reference Portfolio review 2015

Correlations							
All global assets are assumed to be fully NZD hedged	DM large cap	DM small cap	EM equities	NZ equities	Global sovereign bonds	Global credit spread return	NZ T-bills
DM large cap	1.0						
DM small cap	0.8	1.0					
EM equities	0.7	0.6	1.0				
NZ equities	0.7	0.6	0.5	1.0			
Global sov. bonds	0.1	0.1	0.1	0.1	1.0		
Global credit spread	0.6	0.5	0.4	0.4	0.1	1.0	
NZ T-bills	0.0	0.0	0.0	0.0	0.0	0.0	1.0

	Volatility	Expected Return
DM large cap	16%	5.0 + 3.5 = 8.5% p.a.
DM small cap	20%	5.0 + 3.8 = 8.8% p.a.
EM equities	26%	5.0 + 4.4 = 9.4% p.a.
NZ equities	18%	5.0 + 2.5 = 7.5% p.a.
Global sovereign bonds	4.5%	5.0 + 0.4 = 5.4% p.a.
Global credit spread	3.5%	0.5% p.a. (on overlay only)
NZ T-bills	-	5.0% p.a.
Foreign treasury bills*	-	4.2% p.a.

** As implied by our currency risk premium assumption of 0.8% p.a.*

C: Peer comparison

Horizon Survey

Since 2010, Horizon Actuarial Services (Horizon) has conducted an annual survey on capital market risk and return assumptions among investment advisors to the pension fund industry. Twenty-three advisors responded to the latest survey in 2014.[7] We summarise the average estimates for asset classes from the 23 respondents that are relevant to the Reference Portfolio review in Table 6 below. The survey did not cover DM small cap, global listed property and NZ equities.

[7] Survey respondents include: AJ Galagher, Aon Hewitt, Bank of New York Melon, Callan Associates, CapTrust, Graystone Consulting, Investment Performance Associates, J. P. Morgan, Macro Consulting Group, Marquette Associates, Meketa Investment Group, Merrill Lynch Global Institutional Consulting, Morgan Stanley Investment Consulting, New England Pension Consultants, Pension Consulting Alliance, The PFM Group, RVK, Segal Rogercasey, SEI, Sellwood Consulting, Towers Watson, UBS and Wurts & Associates. See: http://www.horizonactuarial.com/blog/2014-survey-of-capital-market-asssumptions/

Table 6: Horizon survey – capital market assumptions

Asset Class	Correlations					Vol.	Exp. Return	Risk Premium
DM equities	1					17.5%	8.0%	4.6%
US small/midcap equities	0.8	1.0				21.1%	8.2%	4.8%
EM equities	0.8	0.7	1.0			26.4%	9.1%	5.7%
Global corporate bonds	0.2	0.2	0.2	1.0		6.1%	4.4%	0.9%
US cash equivalents	-0.1	-0.3	-0.2	0.3	1.0	2.3%	3.5%	0.0%

The survey is primarily US based and therefore most asset classes are separated into US and non-US categories in the survey questions. In Table 6, we combine the average risk and return estimates for US/non-US equities and bonds to arrive at the respective global estimates.[8] Also, the survey did not include DM small cap and so we can only include US small/medium cap in the table. In making any comparisons with our risk and return assumptions, we should bear in mind that our cash rate assumption is 1.5% higher (5% versus an average of 3.5%) and that we assume all global assets are fully NZD hedged.

Volatility assumptions

The average volatility assumptions used by the 23 survey respondents are shown against our volatility assumptions in Table 7.

Table 7: Comparison of volatility assumptions

Asset Class	Volatility Horizon Survey	Volatility NZSF
DM equities	17.5%	16.0%
US small/midcap (DM small cap)	21.1%	20.0%
EM equities	26.4%	26.0%
Global corporate bonds	6.1%	6.0%*
US cash equivalents/NZ T-bills	2.3%	2.1%

** Calculated based on the 4.5% and 3.5% volatility assumptions on term premium and credit spread and the 0.1 correlation assumption between them.*

As shown in the table, our volatility assumptions are very close to the average assumptions used by respondents in the survey. The biggest difference lies in developed global equities where our 16% volatility assumption is 1.5% lower than the average assumption of 17.5%. The difference could be partly explained by the difference in currency hedging assumption.

Correlation assumptions

The average correlation assumptions used by the 23 survey respondents are shown against our correlation assumptions (in brackets) in Table 8.

[8] We used a 55% weight for the US and a 45% weight for non-US assets, with a correlation of 0.8 between the two.

Table 8: Comparison of correlation assumptions: Survey (NZSF)

Asset Class	Equities DM	US Small (Global Small)	Equities EM	Global Corporate	US Cash (NZ Cash)
DM Equities	1.0				
US small/midcap (DM small cap)	0.8 (0.8)	1.0			
EM equities	0.8 (0.7)	0.7 (0.6)	1.0		
Global corporate bonds*	0.2 (0.4)	0.2 (0.4)	0.2 (0.4)	1.0	
US cash equivalents (NZ T-bills)	-0.1 (0.0)	-0.3 (0.0)	-0.2 (0.0)	0.3 (0.0)	1.0

** NZSF's corporate bond correlation assumptions are not explicitly stated but they can be derived based on our term premium and credit spread correlation assumptions.*

As shown in the table, our correlation assumptions among equity assets are close to the average assumptions used by respondents in the survey. On the other hand, our correlation assumptions for global corporate bonds and equity assets (at 0.4 rounded) are substantially higher than the average assumptions (at 0.2 rounded). However, our higher correlation assumptions are more in line with observed correlations in recent time periods and if these correlations turn out to be lower, our Reference Portfolio will have a lower risk than what we assume.

Unfortunately the survey does not include the correlation between government bonds and global equities and therefore we are unable to provide a direct comparison against our assumption of 0.1. However, our 0.1 bond-equity correlation assumption is consistent with the observed average correlation over the period between 1927 and 2013, and we remain comfortable with the implied risk premium based on this estimate.[9]

The other significant difference lies in the correlation assumptions between cash and other assets. Our zero correlation assumption for cash and any other asset is consistent with our choice of cash as the risk-free asset. A non-zero correlation assumption would imply a risk premium for cash. In any case, the correlation assumptions for cash do not feature in any risk calculation for the Reference Portfolio.

Effects of different assumptions at the portfolio level

One way to assess the materiality of the differences in assumptions is to look at how the risk and expected return of the Reference Portfolio would change if we were to substitute our assumptions with the average assumptions from the Horizon survey. We conducted the exercise on our 2010 Reference Portfolio and the results are shown in Table 9. In this exercise, we replaced our DM small cap assumptions with the US small/medium cap average but kept other assumptions not available from the survey (NZ equities and global listed property) the same.

Table 9: Impact on Reference Portfolio risk and expected return (gross, before tax & costs)

2010 Reference Portfolio	NZSF assumptions	Horizon survey average assumptions
Expected Return (above cash)	2.9%	3.7%
Volatility	13.2%	14.1%
Sharpe Ratio	0.22	0.26

[9] See "The Stock-Bond Correlation", PIMCO Quantitative Research November 2013.

If we were to replace our key assumptions with those from the survey and apply them to the 2010 Reference Portfolio, the volatility estimate for the Reference Portfolio would be 0.9% higher (14.1% instead of 13.2%), while the expected return above cash would be 0.8% higher (3.7% instead of 2.9%). The implied Sharpe ratio would also be higher at 0.26 (=3.7%/14.1%) compared to 0.22 (=2.9%/13.2%).

We believe that, overall, our slightly lower risk and lower expected return long-run assumptions are broadly in line with those used by others in the industry.

Appendix 8: Simulation results

A: Characteristics of candidate portfolios

Makeup of the candidate portfolios

We analysed the risk and return characteristics of three candidate portfolios that shared the following attributes:

- Foreign assets are fully currency hedged to the New Zealand dollar (NZD).
- There is a 5% allocation to New Zealand (NZ) equities.
- There is no overweight to global listed property (there had been in 2010).
- The allocation to emerging market (EM) equities were separate from developed market (DM) equities, with a higher weight that better represents EM's market capitalisation weight.

Table 1 sets out the candidate portfolios, which differ of terms of their overall weight to growth as opposed to fixed interest assets.

Table 1: Candidate portfolios

Candidate Portfolios	A (70/30)	B (80/20)	C (90/10)	2010 Reference
DM large cap equities NZD hedged	49.0%	56.6%	64.1%	54.0%
DM small cap equities NZD hedged	7.3%	8.5%	9.6%	8.0%
EM equities NZD hedged	8.7%	10.0%	11.3%	8.0%
NZ equities	5.0%	5.0%	5.0%	5.0%
Global property NZD hedged	-	-	-	5.0%
Global fixed Interest*	30.0%	20.0%	10.0%	20.0%
Risk and Return Characteristics over a 30-year horizon				
Volatility p.a.	12.0%	13.5%	14.9%	13.2%
Expected return p.a. gross (with cash at 5% p.a.)	7.7%	8.0%	8.3%	7.9%
Sharpe ratio	0.22	0.22	0.22	0.22
5% of outcomes are worse than (p.a.)	4.3%	4.2%	4.1%	4.2%
1% of outcomes are worse than (p.a.)	2.8%	2.6%	2.3%	2.6%

* *Composed of sovereign bonds and corporate bonds at the weights implied by the Barclays Capital Global Aggregate Index (currently around 50/50).*

Risk and return characteristics

The volatility, expected return and simulated tail risk estimates are also shown in the bottom panel of Table 1. We note that the risk-return trade-off is close to constant (or linear) within the range of growth/income mix under consideration. For example, when the growth allocation is changed by 10% increments from portfolio A to portfolio B and then portfolio C, portfolio volatility goes up at an increment of 1.5%, while portfolio expected return goes up

by an increment of 0.3%. As a result, the Sharpe ratios for all the portfolios, when rounded to the second decimal place, are the same at 0.22. Therefore, choosing a reference portfolio within this range is primarily a risk preference decision rather than a portfolio optimality decision.

We use the 1st and 5th percentiles as our tail risk metrics for comparison. For example, the 1st percentile of simulated returns for candidate portfolio A (70/30) is at 3.3% p.a., i.e. 1% of simulated returns are worse than 3.3% p.a. We note than the annualised tail risk metrics in Table 1 are not that sensitive to the growth/income mix over a 30-year horizon. However, the differences in the tail risk metrics for the candidate portfolios will be more pronounced over shorter time horizons, which will be discussed in section B below.

In Appendix 9, we present results of Monte Carlo simulations on the candidate reference portfolios under a range of sensitivity and scenario analyses including:

- Long-run risk premium assumptions: we examine the impact of changing the equity risk premium by +/-100 basis points.
- Volatility assumptions: we examine the impact of increasing the global equity volatility assumption from 16% to 18% (with proportionate increases in all other volatility assumptions).
- Foreign currency hedging: we progressively lower the degree of currency hedging under the base case NZ sovereign risk premium.
- Alternative funding start dates: we look at outcomes under the status quo (2020/21) and under the case of no more funding from now on.

B: Results

Simulated outcomes for candidate portfolios over different time horizons

To start, we summarise the simulated performance outcomes of the candidate portfolios in Table 1 above over 1-year, 3-year and 30-year horizons. The results are shown in Table 2.

Table 2: Simulated performance outcomes over different time horizons

Chance of outperformance & downside losses	A (70/30)	B (80/20)	C (90/10)	2010
Outcomes over 1-year horizon				
Probability Return > CPI	71.9%	71.0%	70.2%	71.1%
Probability Return > NZ T-bill	62.6%	62.6%	62.7%	62.6%
Probability Return > NZ T-bill + 2.5%	54.2%	55.2%	56.0%	55.0%
5% of outcomes are worse than	-11.2%	-13.1%	-15.2%	-12.7%
1% of outcomes are worse than	-21.8%	-25.2%	-28.7%	-24.5%
Outcomes over 3-year horizon				
Probability Return > CPI	82.1%	80.6%	79.3%	80.8%
Probability Return > NZ T-bill	68.5%	68.2%	67.9%	68.2%
Probability Return > NZ T-bill + 2.5%	54.2%	55.6%	56.6%	55.2%
5% of outcomes are worse than (p.a.)	-3.5%	-4.7%	-5.9%	-4.5%
1% of outcomes are worse than (p.a.)	-9.7%	-11.8%	-14.0%	-11.5%

Chance of outperformance & downside losses	A (70/30)	B (80/20)	C (90/10)	2010
Outcomes over 30-year horizon				
Probability Return > CPI	99.9%	99.8%	99.7%	99.8%
Probability Return > NZ T-bill	94.3%	93.5%	92.7%	93.3%
Probability Return > NZ T-bill + 2.5%	56.7%	61.0%	63.6%	59.6%
5% of outcomes are worse than (p.a.)	4.3%	4.2%	4.1%	4.2%
1% of outcomes are worse than (p.a.)	2.8%	2.6%	2.3%	2.6%

We look at the chance of the candidate portfolios outperforming each of three 'benchmarks': rate of inflation, cash and 'cash plus 2.5%' over 1-year, 3-year and 30-year horizons, with the last benchmark being the current return expectation of the 2010 Reference Portfolio.

We can see in Table 2 that the chance of the candidate portfolios outperforming each of the three benchmarks improves as the time horizon lengthens. This happens since the expected returns for the candidate portfolios are above all three benchmarks and the excess amount accumulates, thus improving the chance of outperformance over time.

The flipside of this is that the downside outcomes will worsen over shorter time horizons. Consider candidate portfolio B (80/20), for instance. One percent of the simulated returns over a 1-year horizon are below -25.2%, while the corresponding figure over a 30-year horizon is +2.6%. Downside risk measures are generally substantially higher over shorter time horizons. Also, over shorter time horizons, the differences in downside risk due to different growth/income mix are more pronounced. For example, over a 1-year horizon, 1% of the simulated returns for portfolio A (70/30) are below -21.8% as opposed to -28.7% for portfolio C (90/10), or a difference of 6.9%. The corresponding difference over a 30-year horizon is only 0.5% p.a. (= 2.8% - 2.3%).

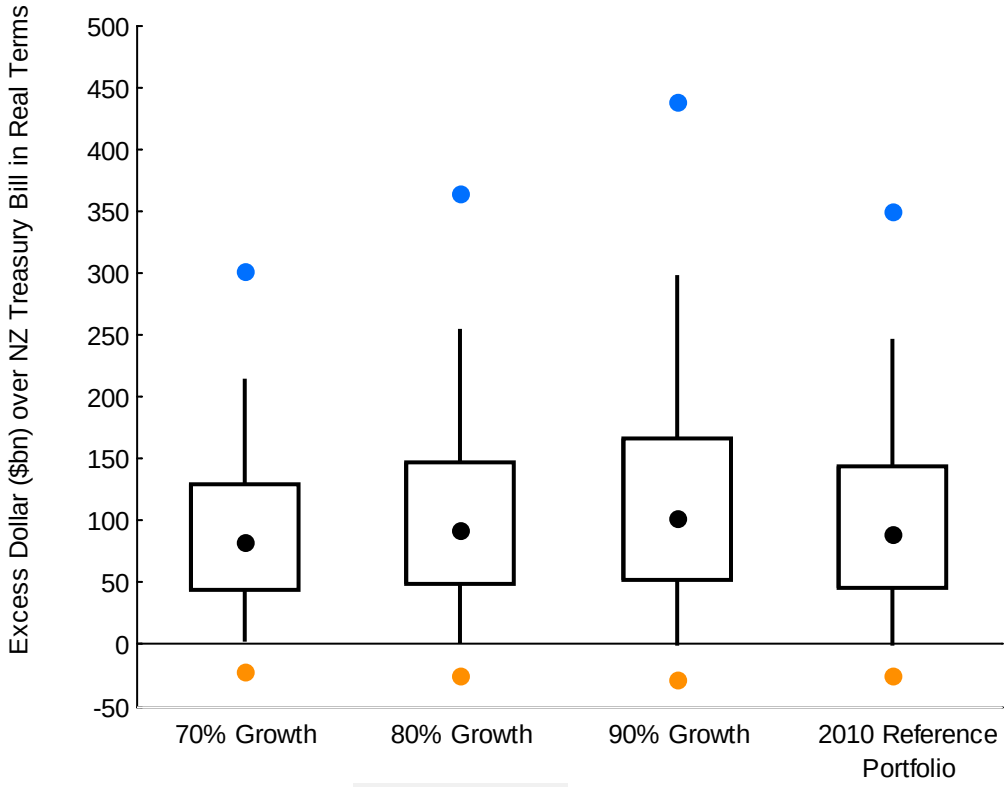
It should be noted that the first percentile 1-year downside risk measure of around -25% for the 80/20 portfolio is different from the -31% figure reported in the *2010 Reference Portfolio Review*. There are two main reasons for the difference. First, we have increased the types of random shocks from 3 to 11 and reduced the magnitude for some of them at the same time, i.e. we have a larger number of smaller shocks this time. Second, we have calibrated the frequencies of occurrence such that the resulting impacts are more in line with observed data.

Simulated outcomes over 30 years versus NZ T-bills

We could also look at how the candidate portfolios perform by looking at the distribution of simulated portfolio values in excess of the value of a portfolio of NZ T-bills over a 30-year horizon. The portfolio of NZ T-bills represents the Crown cost of funding and the excess amount is a measure of the Reference Portfolio's value add over its funding source. The distributions of outcome, reported in real dollar terms ($bn), are shown in Figure 1.

Our simulation results suggest that the net value add over NZ T-bills increases by about $14bn for every 10% increase in growth assets from candidate portfolio A to C. On the other hand, over the same horizon, the first percentile downside risk only worsens by $3bn to $4bn as we move from portfolio A to C. This provides another perspective of the figures reported in Table 2 above that conventional downside risk metrics (such as the probability of a negative return) improve over time due to the portfolio's accumulating returns.

Figure 1: Simulated performance outcomes over a 30-year horizon: Excess NZD over NZ Treasury Bill (in $bn and real terms)



	70% Growth	80% Growth	90% Growth	2010 Reference Portfolio
99th percentile	**301**	**364**	**437**	**349**
95th percentile	215	255	298	246
75th percentile	129	147	166	143
median	**82**	**92**	**101**	**89**
25th percentile	45	48	52	46
5th percentile	2	0	-2	0
1st percentile	**-21**	**-25**	**-28**	**-24**
Expected	92	106	119	102

Appendix 9: Sensitivity of simulation results to alternative risk and return scenarios

A: What do we mean by risk?

Risk, or volatility of returns, is generally used to refer to the variation associated with an asset's returns. The risk of equity returns, for example, is quantified as a 16% p.a. volatility around an expected return of 8.5% p.a. In addition, there is also uncertainty associated with our assumed parameters (e.g. mean, volatility and correlation) of the underlying distribution of returns, as well as the shape of the distribution itself. This uncertainty adds to the overall risk associated with the Reference Portfolio long-run outcomes, with "risk" now encompassing a broader source of variations from our expectations.

In additional to the hidden risk of parameter uncertainty, there is a growing stream of research which suggests many of the risk premia that investors earn largely represent a compensation for bearing disaster risks, i.e. low-frequency but high-impact events that investors might not have experienced – or seen in the historical distribution – due to their rarity. This could help explain why the equity risk premium has been significantly higher and interest rates lower than what traditional asset pricing theories predict; and why the New Zealand dollar (NZD) risk premium and other "carry trade" types of risk premium exist.

A recent survey of the disaster risk literature finds that, based on a wide panel of country-level economic history, there may be a 2% chance of a disaster resulting in a large and rapid decline in aggregate consumption (29% on average).[10] Most of these disasters relate to the Great Depression or the two World Wars. A standard calibration of a disaster risk model to the observed historic disasters explains the observed interest rate and equity risk premium with reasonable assumptions for risk aversion and discount rates. In such a model, the observed (in the absence of disasters) sample equity risk premium is 36 basis points lower than the true population equity risk premium. It is the size of the shocks when they occur, not their impact on the average risk premium, that allows this model to explain the observed equity risk premium.

B: Scenario and sensitivity analysis

Sensitivity analysis provides the means of getting a better handle on the impact of uncertainty on the true risk and return characteristics of the Reference Portfolio. With the use of different assumed values of model parameters, we get a sense of which assumptions in the modelling process are critical to obtaining our baseline set of results.

In addition, we also draw on the expanded macroeconomic scenario work done since the 2010 Reference Portfolio review to map out the likely impact of a number of generic shocks that could eventuate over our investment horizon. These events are modelled as 1-in-20 year positive or negative shocks impacting at a global level. We also include scenarios that impact specifically on New Zealand (NZ) with implications for the local dollar, equities, inflation and interest rates.

As was with the case with the 2010 review, the primary purpose of scenarios is to allow us to mold the simulated return distributions so that they better fit with our priors. Specifically, the distribution with overlaid scenarios features fatter tails (excess kurtosis) and some negative skew. Scenarios also allow us to incorporate some intuition of how asset classes interrelate out of equilibrium: for example, that government bond returns become negatively correlated with equity returns in crises due to monetary policy responses, or that the NZD is vulnerable to sharp depreciation in a NZ economic downturn.

[10] "Disaster Risk and its Implications for Asset Pricing", Jerry Tsai and Jessica A. Wachter, NBER Working Paper Series #20926, 2015.

We believe that this type of scenario analysis can provide a richer context for assessing potential portfolio outcomes.

Sensitivity test and scenario descriptions

A list of scenarios that we have modelled in this review is contained in Panel A of Table 1. In Panel B of the same table, we provide a list of the key assumptions and the corresponding range of assumed values used in the sensitivity analysis. In Panel C we list and describe the key variables that we monitor in our simulation results.

Table 1: Summary of scenarios, range of key parameter values and variables of interest

Panel A: Scenario	Brief description
Global Financial Crisis	This crisis is similar in nature to the 2008-09 Global Financial Crisis, with sharp sell-offs in financial assets, and increased correlations (even for diversifiers), but ultimately a rapid recovery in response to stimulative monetary policy.
Supply shock	This is a classic negative aggregate supply shock driven by higher energy prices
Emerging market (EM) crisis	This is a global shock originating in a sharp slowdown in EM demand. The catalyst is the popping of a credit bubble in China.
High-inflation world	Developed economy inflation slowly rises out of control
Commodity price deflation	In this scenario real commodity prices mildly decline over a 30 year period, in line with the historical experience (agriculture in particular)
EM promise realised	In this scenario EM returns are higher than our equilibrium risk assumptions on the basis that they realise the promise of convergences to DM productivity levels.
Positive productivity shock	This scenario is styled on the US tech boom - global and EM equities rally strongly and eventually come off (though retain some gains), while the cycle in other asset classes and NZ equities is much more muted.
Western lost decade	Western economies undergo a prolonged period of weak growth and deflation, analogous to the experience of Japan, with no correction to the previous trend growth rate.
Long-lasting NZ shock	A symmetric shock where NZ experiences of protracted weak(/strong) growth relative to the rest of the world, resulting in NZD and asset price depreciation (/appreciation)
NZ disastrous shock	A 1-in-200 year disaster befalls NZ resulting in a permanent reduction in NZ's trend growth level
High-inflation NZ	NZ inflation rises to high rates due to the weakening of RBNZ independence
Panel B: Sensitivity assumption	**Assumed values**
Equity risk premium	2.5%, 4.5% (cf. 3.5%)
Volatilities	18% (cf.16%)
Hedge ratio on foreign assets	75%, 50% (cf. 100%)
Resumption of contribution	Never, 2020/21 (currently scheduled)

Panel C: Key variables	Brief description
Long-run return over CPI	Probability of Fund returns exceeding the rate of inflation
Long-run return over NZ T-bills	Probability of Fund returns exceeding the rate of return on NZ T-bills
Long-run return over NZ T-bills + 2.5%	Probability of Fund returns exceeding the rate of return on NZ T-bills +2.5%p.a.
5th and 1st percentile left tails	The compound return over the stated horizon was less than or equal to this value in 5% (/1%) of the simulations

Scenario results

Table 2 provides a summary of the equilibrium impact on the Reference Portfolio of the various scenarios considered, averaged over the 10 year horizon that the scenario impacts upon (assuming an 80/20 portfolio).

Table 2: Summary of scenarios, range of key parameter values and variables of interest

Reference portfolio return for 80/20 candidate portfolio				
Compound Return over:	**1 year Worst year**	**10 year Nominal**	**10 year Real**	**10 year Excess to NZ T-bill**
Equilibrium	8.0%	8.0%	5.9%	2.9%
Global Financial Crisis	-28.6%	5.5%	4.4%	2.6%
Supply shock	-12.9%	6.5%	4.2%	1.5%
EM Crisis	-13.2%	5.9%	4.7%	3.0%
High-inflation world	-4.8%	5.9%	3.3%	0.3%
Commodity price deflation	7.0%	8.2%	6.0%	3.1%
EM promise realised	8.0%	8.1%	6.0%	3.0%
Positive productivity shock	-11.1%	9.7%	7.3%	4.2%
Western lost decade	-18.5%	3.1%	2.6%	0.3%
Long-lasting NZ shock (+ve)	5.0%	7.1%	4.8%	2.8%
Long-lasting NZ shock (-ve)	7.9%	8.9%	7.0%	2.9%
NZ disastrous shock	3.0%	5.4%	3.7%	2.7%
High-inflation NZ	7.5%	9.7%	5.3%	2.6%

Sensitivity to the equity risk premium assumption

In this section we examine the impact of changing the equity risk premium (ERP) equilibrium assumption of 3.5% by ±1%. We note that an equity risk premium of 2.5% is an extremely conservative assumption relative to the 3.1% ERP implied by the disaster risk literature. For succinctness, we present results only for portfolio B (the 80/20 candidate portfolio). These results are shown in Table 3 and Figure 1.

The change in ERP only affects the expected return of the portfolio. Therefore, as expected, an increase (decrease) in ERP improves (lowers) the chances of the candidate portfolios outperforming any given benchmark. Similarly, an increase (decrease) in ERP also improves (worsens) the downside risk metrics over any time horizon.

Table 3: Simulated performance outcomes for portfolio B at varying ERP

Chance of outperformance & downside losses	ERP=2.5%	ERP=3.5%	ERP=4.5%
Outcomes over 1-year horizon			
Probability Return > CPI	68.8%	71.0%	73.1%
Probability Return > NZ T-bill	60.2%	62.6%	65.0%
Probability Return > NZ T-bill + 2.5%	52.7%	55.2%	57.7%
5% of outcomes are worse than	-14.0%	-13.1%	-12.3%
1% of outcomes are worse than	-26.1%	-25.2%	-24.4%
Outcomes over 3-year horizon			
Probability Return > CPI	77.5%	80.6%	83.4%
Probability Return > NZ T-bill	64.1%	68.2%	72.1%
Probability Return > NZ T-bill + 2.5%	51.0%	55.6%	60.0%
5% of outcomes are worse than (p.a.)	-5.5%	-4.7%	-3.8%
1% of outcomes are worse than (p.a.)	-12.6%	-11.8%	-10.9%
Outcomes over 30-year horizon			
Probability Return > CPI	99.4%	99.8%	99.9%
Probability Return > NZ T-bill	86.9%	93.5%	97.3%
Probability Return > NZ T-bill + 2.5%	44.6%	61.0%	75.4%
5% of outcomes are worse than (p.a.)	3.4%	4.2%	5.1%
1% of outcomes are worse than (p.a.)	1.7%	2.6%	3.4%

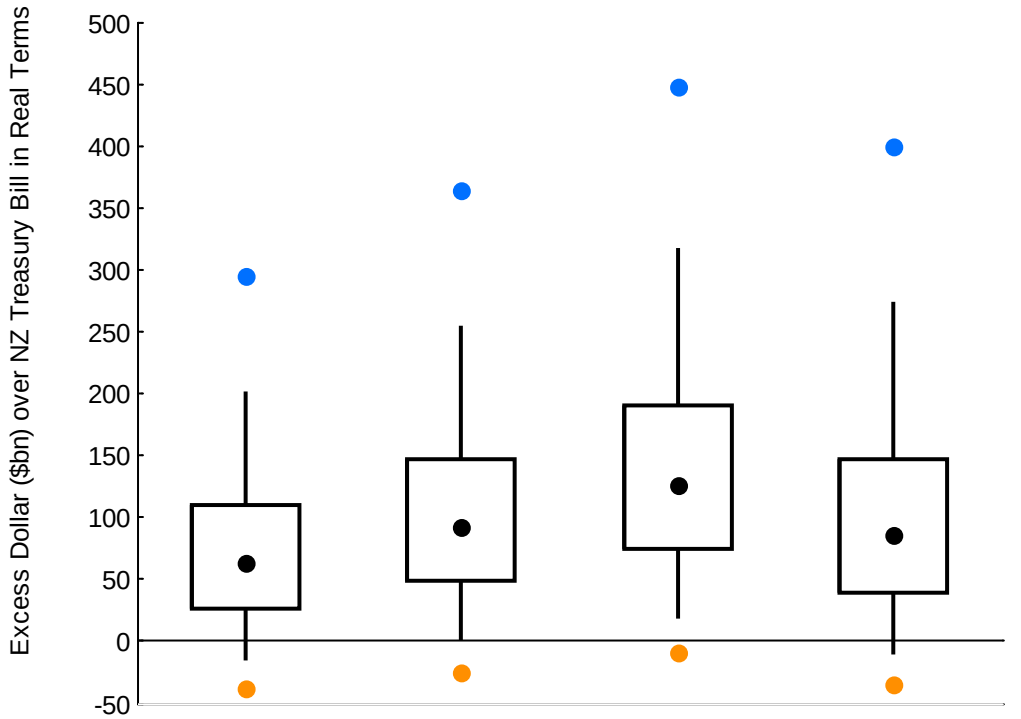
We have also looked at how sensitive the net value add amount is to a change in the ERP assumptions. For succinctness, we only report results for portfolio B and over a 30-year horizon in Figure 1. As shown in the figure, the impact of a change in ERP has a larger effect on the expected value add – every 1% increase in the ERP assumption raises the expected net value add by around $30bn. The impact of a 1% change in ERP on expected value add is larger than the impact of a 10% increase in growth allocation. This is anticipated since, other things being equal, a 1% increase in ERP leads to roughly an 0.80% (=80%x1%) increase in expected return for an 80/20 portfolio; while a 10% increase in growth allocation would increase the portfolio expected return roughly by 0.35% (=10%x3.5%).

Sensitivity to volatility assumptions

In this section we look at the impact of higher volatility assumptions by increasing assumed volatility of developed market (DM) large cap equities from 16% to 18% and with a proportionate increase in all other volatility assumptions. Again, for succinctness, we present results only for portfolio B (the 80/20 candidate portfolio) in Table 4. The distribution of net value add under the higher volatility assumption is shown in the last column in Figure 1.

The higher volatility assumptions have slight impacts on the chance of portfolio B outperforming the three different benchmarks. The larger impacts are on the downside risk metrics, especially those over the two shorter time horizons. For example, one percent of the simulated returns over a 1-year horizon are now worse than -28.4% rather than -25.2%.

Figure 1: Net value add for portfolio B over 30-years at varying ERP and 18% vol.



	2.5% ERP,16% vol	3.5% ERP,16% vol	4.5% ERP,16% vol	3.5% ERP,18% vol
99th percentile	**295**	**364**	**447**	**399**
95th percentile	201	255	318	273
75th percentile	110	147	191	147
median	**63**	**92**	**126**	**86**
25th percentile	26	48	74	39
5th percentile	-15	0	19	-11
1st percentile	**-38**	**-25**	**-10**	**-35**
Expected	75	106	142	103

Table 4: Simulated performance outcomes for portfolio B at higher volatility assumptions

Chance of outperformance & downside losses	At assumed volatilities (16% for DM large cap, etc.)	At higher volatilities (18% for DM large cap, etc.)
Outcomes over 1-year horizon		
Probability Return > CPI	71.0%	68.6%
Probability Return > NZ T-bill	62.6%	61.1%
Probability Return > NZ T-bill + 2.5%	55.2%	54.5%
5% of outcomes are worse than	-13.1%	-15.9%
1% of outcomes are worse than	-25.2%	-28.4%

Chance of outperformance & downside losses	At assumed volatilities (16% for DM large cap, etc.)	At higher volatilities (18% for DM large cap, etc.)
Outcomes over 3-year horizon		
Probability Return > CPI	80.6%	77.2%
Probability Return > NZ T-bill	68.2%	65.5%
Probability Return > NZ T-bill + 2.5%	55.6%	54.1%
5% of outcomes are worse than (p.a.)	-4.7%	-6.3%
1% of outcomes are worse than (p.a.)	-11.8%	-13.5%
Outcomes over 30-year horizon		
Probability Return > CPI	99.8%	99.5%
Probability Return > NZ T-bill	93.5%	89.8%
Probability Return > NZ T-bill + 2.5%	61.0%	56.0%
5% of outcomes are worse than (p.a.)	4.2%	3.6%
1% of outcomes are worse than (p.a.)	2.6%	1.8%

Sensitivity to the currency hedge ratio

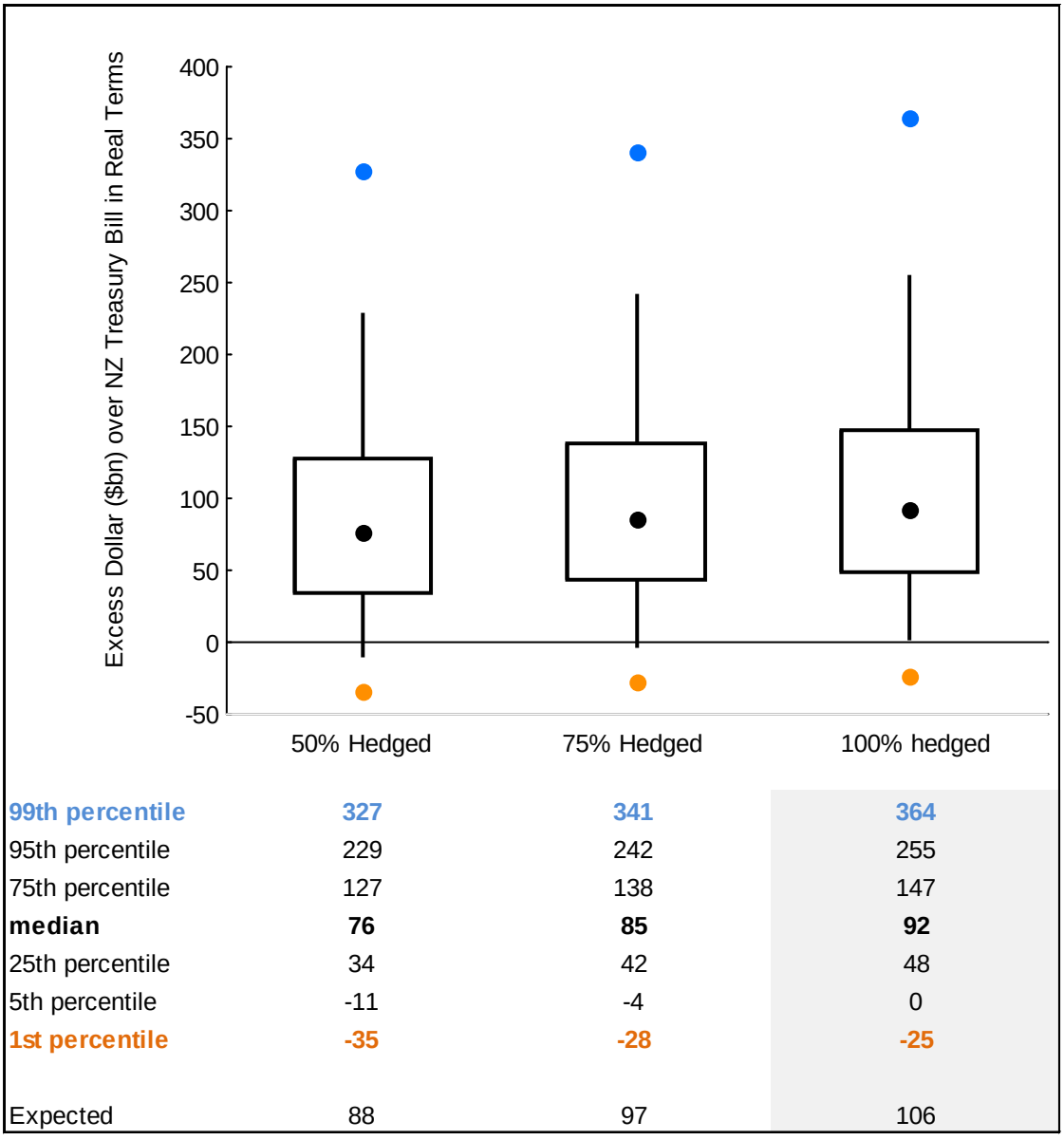
In this section we investigate the impact of the currency hedge ratio on portfolio B (the 80/20 candidate portfolio) at hedge ratios of 100%, 75% and 50%. In varying the hedge ratio, we maintain the assumption that there is a currency hedging risk premium of 0.8%, i.e. the expected return on a fully currency hedged global asset is 0.8% higher than that of the unhedged counterpart. The results are shown in Table 5 and Figure 2.

Table 5: Simulated performance outcomes with different currency hedging assumptions

Chance of outperformance & downside losses	100% Hedge	75% Hedge	50% Hedge
Outcomes over 1-year horizon			
Probability Return > CPI	71.0%	70.7%	69.8%
Probability Return > NZ T-bill	62.6%	61.9%	61.0%
Probability Return > NZ T-bill + 2.5%	55.2%	54.3%	53.4%
5% of outcomes are worse than	-13.1%	-12.7%	-13.3%
1% of outcomes are worse than	-25.2%	-23.2%	-23.9%
Outcomes over 3-year horizon			
Probability Return > CPI	80.6%	80.5%	79.4%
Probability Return > NZ T-bill	68.2%	67.5%	65.8%
Probability Return > NZ T-bill + 2.5%	55.6%	54.5%	53.0%
5% of outcomes are worse than (p.a.)	-4.7%	-4.5%	-5.1%
1% of outcomes are worse than (p.a.)	-11.8%	-11.1%	-11.9%

Chance of outperformance & downside losses	100% Hedge	75% Hedge	50% Hedge
Outcomes over 30-year horizon			
Probability Return > CPI	99.8%	99.9%	99.8%
Probability Return > NZ T-bill	93.5%	92.3%	89.9%
Probability Return > NZ T-bill + 2.5%	61.0%	57.6%	52.2%
5% of outcomes are worse than (p.a.)	4.2%	4.1%	3.9%
1% of outcomes are worse than (p.a.)	2.6%	2.6%	2.3%

Figure 2: Net value add for portfolio B over 30-year at varying currency hedge ratio



	50% Hedged	75% Hedged	100% hedged
99th percentile	**327**	**341**	**364**
95th percentile	229	242	255
75th percentile	127	138	147
median	**76**	**85**	**92**
25th percentile	34	42	48
5th percentile	-11	-4	0
1st percentile	**-35**	**-28**	**-25**
Expected	88	97	106

When we lower the currency hedge ratio, the portfolio's expected return will also be lower because we are giving up some NZD risk premium. At the same time, the downside risk of the candidate portfolios improves since foreign currencies provide some form of tail risk hedging in some scenarios used in the simulation. We need to be aware of both of these effects when interpreting results reported in Table 5. For instance, consider the first

percentile outcomes in the top panel of Table 5. One percent of simulated returns are below -23.2% under the 75% hedge scenario, which is a 2% improvement over the -25.2% figure under the 100% hedge scenario, despite the slight drop in expected return (see Figure 2). However, when the hedge ratio is further reduced to 50%, the first percentile is at -23.9%, which is slightly worse than the -23.3% under the 75% hedge scenario. This suggests that, over a 1-year horizon, the further drop in expected return has a marginally larger impact on downside risk than any tail risk reduction effected by the additional foreign currencies.

The simulation results are consistent with our analysis that there is a slight risk reduction as we introduce foreign currencies into the Reference Portfolio, although the impact of lower expected returns quickly outweighs the risk reduction benefits of having foreign currencies in the portfolio.

Sensitivity to the resumption of contributions

The Government has indicated an intention to resume contributions to the Fund when "net core Crown debt falls below 20% of GDP". Based on current Treasury forecasts, contributions will resume in 2020/21, and continue until 2030/31, when withdrawals are forecast to begin.

In addition to this 'status quo' scenario for contributions, we also model a scenario where no further contributions are ever made. In both cases the NZSF Contribution Rate model[11] is used dynamically to determine the timing as well as size of contributions (when allowed) and withdrawals. The results are shown in Figure 3 over the page.

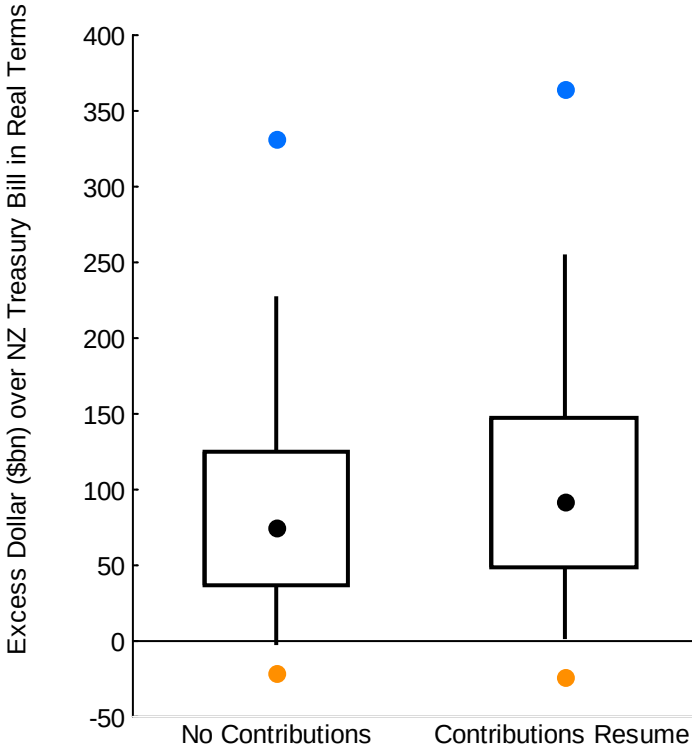
As contributions do not change the underlying return distribution, they do not change the probability of time-weighted returns exceeding various benchmarks. However, it should be noted that because the funding formula results in higher contributions (or lower withdrawals) when returns have been low, it does smooth out some of the volatility in the size of the Fund over time.

Naturally, under the scenario of no further contributions, the median forecast for the Fund's net value add would be $18bn lower than status quo. The forecast Fund size in 30 years of 18.2% of GDP would be 4.2 percentage points lower than under the status quo.

To the extent that the absence of additional contributions would threaten the Fund's ability to "reduce New Zealanders' future tax burden", an alternative Reference Portfolio could be chosen with greater exposure to growth assets to increase the expected value-add to the Crown (over our benchmark 30-year horizon). Our calculations suggest that a portfolio with 92.5% in growth assets, and no additional contributions, would have a similar expected value-add as an 80% growth portfolio that received contributions in line with our base case assumption of contributions resuming at 2020/21. Although this higher growth portfolio would have a similar expected value-add, there would be a considerable increase in risk, and thus uncertainty, around the expected mean. Figure 4 illustrates the simulated distribution associated with this higher growth portfolio.

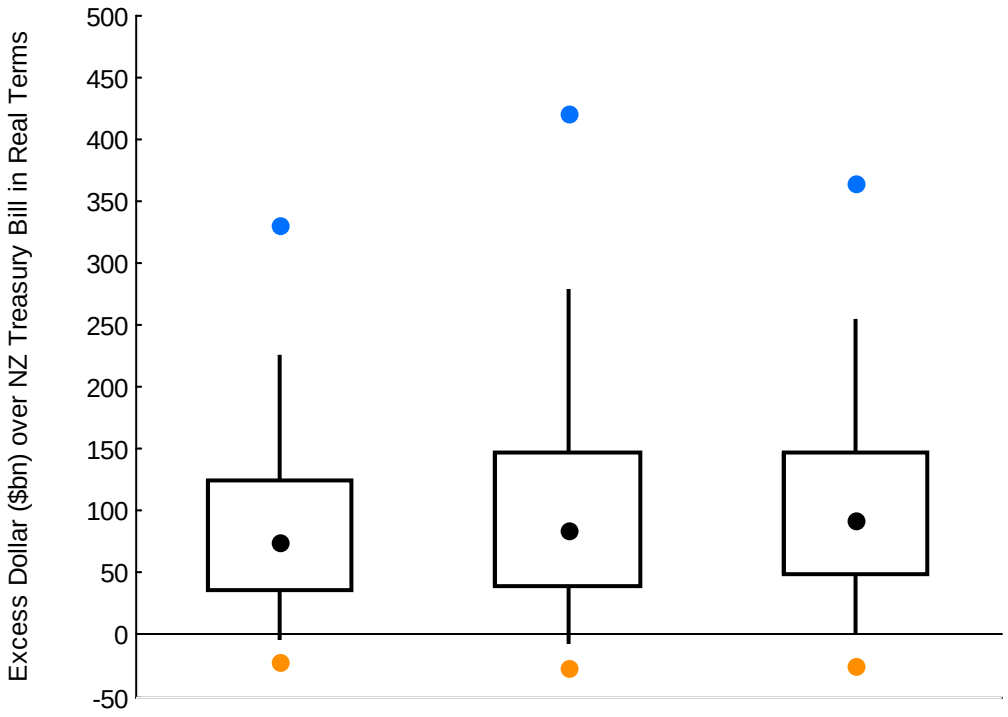
[11] The model used by Treasury to forecast the size of contributions/withdrawals to or from the Fund, which can be found at: http://www.treasury.govt.nz/government/assets/nzsf/contributionratemodel

Figure 3: Net value add for portfolio B over 30-year under two contribution scenarios



	No Contributions	Contributions Resume 2020/21
99th percentile	**331**	**364**
95th percentile	226	255
75th percentile	125	147
median	**74**	**92**
25th percentile	36	48
5th percentile	-4	0
1st percentile	**-21**	**-25**

Figure 4: Required growth exposure to compensate for no contributions (in expected value add over 30-years)



	No Contributions, 80% Growth	No Contributions, 92.5% Growth	Contributions Resume 2020/21
99th percentile	**331**	**420**	**364**
95th percentile	226	279	255
75th percentile	125	148	147
median	**74**	**85**	**92**
25th percentile	36	39	48
5th percentile	-4	-7	0
1st percentile	**-21**	**-26**	**-25**
Expected	88	105	106