New Zealand Superannuation (NZS) Fund Contribution Rate Model Modelling Guide

22 May 2009

Background

The objective of the New Zealand Superannuation (NZS) Fund is to "*provide for both current and future payment of New Zealand superannuation entitlements*". The NZS Fund was established by the New Zealand Superannuation and Retirement Income Act (2001).

The management and administration of the NZS Fund is done by an independent Crown entity called the Guardians of New Zealand Superannuation.

The Treasury is responsible, as defined in the Act, for calculating the amount of the annual capital contribution each financial year. The primary purpose of the NZS Fund model is to perform this calculation. All assumptions and judgements used in this calculation must be stated in the Economic and Fiscal Update (EFU) in which the contribution is published.

Introduction

The NZS Fund model is an Excel spreadsheet, consisting of several worksheets, namely:

Start Here Simply gives information about the model, and how to use it.

Input All input data to the model is entered on this worksheet. There are instructions clarifying what should be entered beside each input cell(s). The "Reset Parameters" macro, for resetting all inputs to their default settings, is also on this worksheet.

Model All of the model's major fiscal variables, such as required contributions, earnings, tax, fund balance etc are calculated and displayed here in annual tracks. The calculations are performed using the data and assumptions given in the "Input" worksheet. It is the formulae in this worksheet that are the main focus of this modelling guide.

Contribution Rate A graph of the pathways of "net NZS expense" and "actual and required capital contributions plus net NZS expense", as a % of GDP, over time. All data in the graph comes from the "Model" worksheet.

Capital Contribution A graph of the pathway of "capital contributions", as a % of GDP, over time. All data in the graph comes from the "Model" worksheet.

Fund Balance A graph of the pathway of "size of Fund assets", as a % of GDP, over time. All data in the graph comes from the "Model" worksheet.

Defaults This worksheet is a copy of the “Input” worksheet used for the latest official version of the model. The data is based on the most recent Treasury economic and fiscal forecasts, usually produced as part of the latest EFU. The “Reset Parameters” macro in “Input” will restore all data in that worksheet to these default settings.

Input worksheet

The inputs in this worksheet are clearly described. Any cell shaded light yellow requires numerical inputs.

“Reset Parameters” button

Pressing this macro button will restore all inputs in the “Input” worksheet to the values in the “Defaults” worksheet. The “Defaults” values are the inputs used for the latest official version of the model, based on the most recent Treasury economic and fiscal forecasts.

Expected before-tax nominal annual rate of return

Enter a single value for the expected rate of return on the NZS Fund’s assets.

This value, representing an arithmetic mean rate of return, remains constant in all years.

Expected tax rate on earnings

Enter a single value for the expected tax rate on the NZS Fund’s earnings.

This value remains constant in all years.

(Note: The Net Present Value calculations for contributions to the Fund use an after-tax rate of return).

Fund balance as at 30 June 2XXX

Enter the Fund closing balance, in billions of dollars, in the last known actual year. This value can be obtained from Financial Statements of the Government of New Zealand for the Year Ended 30 June 2XXX, or from the Treasury website: http://www.treasury.govt.nz/

Legislated parameters

Entries can be made for the funding horizon and the first fiscal year for drawdowns.

The funding horizon is the period on which Net Present Value calculations of the contributions to the Fund are based.

Note: As these parameters are set by legislation, they would not be changed in most modelling scenarios.

Constraints to the logic of the model

Values entered in each year, in billions of dollars, will be used by the model in place of the amount it would otherwise calculate. If nothing is entered, the model will calculate the value in that year.

Annual values can be entered for capital contributions (in excess of net NZS expenditure), earnings on assets and tax on these earnings.

Note: The capital contribution will normally be constrained in the first forecast year, even if no constraints are applied to later years. The figure for this first fiscal year is communicated to the Guardians of NZS for their investment planning, and they receive it in fortnightly instalments throughout the year, so is not usually changed at future updates or in alternative scenarios.

Forecasts of earnings and tax are provided by the Guardians for the latest EFU years. These are used in calculating the capital contribution track.

One-off endowments

Values entered in each year, in billions of dollars, allow for any one-off endowments to the Fund in that year.

GDP, NZS expenditure and structural limit

Capital contribution calculations use nominal GDP and net NZS tracks for the latest EFU.

The structural limit on the annual capital contribution can be entered, but by default is calculated as GDP – net NZS. This recognises a theoretical upper bound on contributions as the entire economy's output, less whatever is required to pay for NZS.

Contribution Rate, Capital Contribution and Fund Balance worksheets

These are all graphs, generated from annual tracks displayed in the "Model" worksheet.

Defaults worksheet

The values in this worksheet are the values used in the "Input" worksheet of the latest official version of the model. These are the most recent economic and fiscal forecasts and projections made by Treasury, normally as part of the most recent EFU.

The "Reset Parameters" macro in the "Input" worksheet will restore all data in that worksheet to these default settings.

Model worksheet

GDP, Net NZS expenditure & Structural limit

Directly picked up, for each year, from the tracks for each variable in the "Input" worksheet.

Capital contribution, Earnings on assets, Tax constraints and One-off endowments

Checks, for each year, whether a value is entered in the "Input" worksheet.

If it has then it picks up the value. Otherwise, sets cell to blank entry.

Funding horizon, Earliest draw on fund assets & Tax rate on fund earnings

Directly picked up from the value for each variable in the "Input" worksheet.

Before-tax nominal annual rate of return on fund assets

Directly picked up from "Expected before-tax nominal annual rate of return" in "Input".

After-tax nominal annual rate of return on fund assets *(r)*

Calculated as: Before-tax rate of return x (1 - Tax rate on fund earnings)

After-tax in-year compound return with fortnightly rests *(v)*

This formula is not obvious, and hence requires some derivation.

The principal (P) is contributed in equal fortnightly instalments with annual interest (r) compounding evenly throughout the year.
v is the interest rate, that would have produced the same balance by the end of the year, had the whole principal been invested for the whole year.

The total annual return on an investment for the whole year = $(1 + r)$

This is equivalent to a compounding fortnightly return of $(1 + f)$, where $(1 + f)^{26} = (1 + r)$

➔ $(1 + f) = (1 + r)^{1/26}$

If fortnightly payments of 1/26 of P are received at the end of each fortnight,
the interest received on the last fortnightly payment is zero,
on the second to last payment is $(P/26)*f = (P/26)*[(1+f) - 1] = (P/26)*[(1+f)^{2-1} - 1]$,

on the jth to last payment is $(P/26)*[(1+f)^{(j-1)} - 1]$ … etc,

and on the first payment ($j = 26$) is $(P/26)*[(1+f)^{25} - 1]$.

Summing these up, the total interest received over the year is:

$$Interest = \sum_{j=0}^{25} \frac{P}{26}\left[(1+f)^{j} - 1\right] = P\left(\sum_{j=0}^{25}\left[\frac{1}{26}(1+f)^{j}\right] - 1\right)$$

Dividing this by P gives v, the equivalent rate of return that would have produced the same end-of-year return if the full principal P had been invested for the whole year.

$$v = \sum_{j=0}^{25}\left[\frac{1}{26}(1+f)^{j}\right]-1 \Rightarrow 1+v = \sum_{j=0}^{25}\frac{1}{26}(1+f)^{j} = \frac{1}{26}\sum_{j=0}^{25}\left[(1+r)^{\frac{1}{26}}\right]^{j} = \frac{1}{26}\sum_{j=0}^{25}(1+r)^{\frac{j}{26}}$$

The final summation is a geometric series of 26 terms, with constant multiplier (1/26) and an increasing power term of $(1+r)^{1/26}$. It is simple to show the summation equals:

$$1+v = \frac{r}{26[(1+r)^{1/26}-1]} \Rightarrow v = \frac{r}{26[(1+r)^{1/26}-1]}-1$$

The final version of the formula shown for *v* is how this is calculated in the model.

Required capital contribution plus net NZS expenditure as % of GDP (CCNZS%Y)

Note: This formula is not obvious.

The derivation can be found in the Treasury working paper "Financing New Zealand Superannuation" at http://www.treasury.govt.nz/publications/research-policy/wp/2001/01-20/.

CCNZS%Y =

$$\frac{NPV_{r,FH}\{\text{net NZS expenditure}\} - (\text{NZS Fund balance in previous year}) \div (1+v)}{NPV_{r,FH}\{\text{nominal GDP}\}}$$

where:

$NPV_{r,FH}\{Z\}$ = the Net Present Value of Z, using the after-tax nominal annual rate of return, *r*, as the discounting rate, over the period *FH,* which is from the current year to the end of the funding horizon

v = after-tax in-year compound return with fortnightly rests

Required capital contribution plus net NZS expenditure as nominal *(CCNZS)*

Calculated as: *CCNZS* = nominal GDP x *CCNZS%Y*

Required capital contribution as % of GDP *(CC%Y)*

Calculated as: *CC%Y* = *CCNZS%Y* – net NZS expenditure ÷nominal GDP

Required capital contribution as nominal *(CC)*

Calculated as: *CC* = *CCNZS* – net NZS expenditure

Minimum contribution including net NZS expenditure *(min CCNZS)*

Checks, for each year, if it is less than the year nominated as the earliest fiscal year to draw upon the NZS Fund.

If true, sets min *CCNZS* = net NZS expenditure.
If false, sets min *CCNZS* = 0.

Maximum contribution including net NZS expenditure *(max CCNZS)*

Calculated as: max *CCNZS* = net NZS expenditure
+ minimum (capital contribution constraint, structural limit)

Note: When capital contribution constraints cease, this just becomes nominal GDP.

Actual capital contribution plus net NZS expenditure *(act CCNZS)*

Calculated as:

1) in years where a constraint has been selected for the capital contribution:
act *CCNZS* = net NZS expenditure + capital contribution constraint

2) otherwise: act *CCNZS* = minimum [maximum(*CCNZS*, min *CCNZS*) , max *CCNZS*]

Note: Generally ensures that the capital contribution plus NZS expenditure cannot exceed the capital contribution constraint plus net NZS expenditure. When the maximum constraint becomes the structural limit, which is effectively GDP, it is unlikely to be binding.

***less* net NZS expenditure**

Calculated as: – net NZS expenditure

Capital contribution (capC)

Calculated as: *capC* = act *CCNZS* – net NZS expenditure

Gross earnings on fund assets

Calculated as:

1) in years where a constraint has been selected for the gross earnings:
Gross earnings constraint

2) otherwise:
(Net earnings on fund assets) ÷ (1 – Tax rate on fund earnings)

***less* Tax paid on earnings on fund assets**

Calculated as:

1) in years where a constraint has been selected for the tax paid on earnings:
Tax on earnings constraint

2) otherwise:
– (Gross earnings on fund assets) x Tax rate on fund earnings

Net earnings on fund assets

Calculated as:

1) in years where a constraint has been selected for the gross earnings:
Gross earnings on fund assets – Tax paid on earnings on fund assets

2) otherwise:
Closing fund balance in previous year x *r* + *capC* x *v*

where: r = after-tax nominal annual rate of return

v = after-tax in-year compound return with fortnightly rests

One-off endowment

Set to One-off endowment

Closing fund balance

Calculated as: Closing fund balance in previous year + *capC*

+ net earnings on fund assets + one-off endowment

Net NZS expenditure as % of GDP, Actual capital contribution plus net NZS expenditure as % of GDP, Capital contribution as % of GDP, Gross earnings on fund assets as % of GDP, Tax paid on earnings on fund assets as % of GDP, Net earnings on fund assets as % of GDP & Closing fund balance as % of GDP

All calculated as: nominal value calculated in worksheet ÷ nominal GDP