

New Zealand Superannuation (NZS) Fund Contribution Rate Model Guide

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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. Of these, only the *Input* and *Model* worksheets are essential to producing the capital contribution/ (withdrawal) calculations, although the opening year Fund variables shown in red in the *Model* worksheet are picked up from the *History of the Fund* worksheet.

A quick description of each worksheet is given here:

Start Here Information about the model, and how to operate it.

NZS expense – History & Future Information about New Zealand Superannuation (NZS) expenditure, both as a % of nominal GDP and in nominal \$ terms, and about NZS recipient numbers. The data, which is in units of fiscal years (i.e. years from 1 July to the following 30 June), includes historical outturns (back to 1996/97), the latest forecast horizon from the Ministry of Social Development (MSD), and the corresponding post-forecast projections produced by the Treasury.

History of NZS Fund Historical data on the Fund's earnings, tax paid, capital contributions from the Crown and closing balances, from its inception in 2001/02 up until the latest completed fiscal year.

Input The vast majority of input data to the model is entered on this worksheet. The only exception is the model's opening year (latest completed fiscal year) Fund variables, which are found in the *History of the Fund* worksheet. There are instructions clarifying what should be entered beside each input cell(s). If any of the standard input assumptions, including the long-run input tracks of nominal GDP, net (of tax) NZS expenditure and the Government medium-term bond rate, are altered, then they can be restored to the latest forecast round values by picking them up from the *Defaults* 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 fiscal year tracks, beginning with the first one beyond the latest completed

fiscal year. 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 model guide.

- Contribution Rate** A graph of the paths of “net NZS expense” and “actual and required capital contributions plus net NZS expense”, as a % of nominal GDP, over a more than 80-year projected future horizon. All data in the graph comes from the *Model* worksheet.
- Capital Contribution** A graph of the path of “capital contributions” from the Crown to the Fund (and in later years “capital withdrawals” from the Fund), as a % of nominal GDP, over a more than 80-year projected future horizon. All data in the graph comes from the *Model* worksheet.
- Fund Balance** A graph of the path of “size of Fund assets”, as a % of nominal GDP, over a more than 80-year projected future horizon. All data in the graph comes from the *Model* worksheet.
- NZS to GDP** A graph of the path of “gross (inclusive of tax) aggregate NZS expenditure”, as a % of nominal GDP, over a more than 60-year time span, including both historical fiscal years and forecast and projected future years. All data in the graph comes from the *NZS expense – History & Future* worksheet.
- Defaults** This worksheet contains all the standard inputs used in the *Input* worksheet used for the latest official version of the model. This includes the long-run input tracks for nominal GDP, net (of tax) NZS expenditure and the Government medium-term bond rate. The data is based on the most recent Treasury economic and fiscal forecasts, usually produced as part of the latest Economic and Fiscal Update (EFU).

Input worksheet

The inputs in this worksheet are clearly described. Any cell shaded light yellow requires numerical inputs. The model will already contain the standard inputs for the latest EFU forecast round in these shaded cells, but they can be altered to produce alternative outcomes if desired.

Expected before-tax nominal annual rate of return

The Fund's own [Performance](#) statement says “*It is our expectation, given our long-term mandate and risk appetite, that we will return at least the Treasury Bill return + 2.5% p.a. over any 20-year moving average period.*”

While it is accepted that this is a minimum expectation (note the term “...return at least...”) it is an acceptable statement on which to base a **conservative** long-run expected rate of return for the Fund. Using recent returns would be a poor choice for a long-run average return rate, as these will always be subject to current market and economic conditions, as well as the frequently changing weightings of asset types in the Fund's portfolio. In other words, while they may reflect return of assets currently being received by the NZS Fund, they are likely to be a poor representation of rates in 5, 10, 20 or 40 years time.

As the Treasury does not actually produce a long-run projection of Treasury Bill returns, but rather one of the medium-term (currently represented as the 5-year) Government bond rate, the assumption is made that this medium-term bond rate is, on average over time, 20 basis points higher than the Treasury Bill rate.

Hence the default setting for this input value to the model, which is the increment to the Government bond rate used to set the expected rate of return on Fund assets, is 2.3%. This means that the expected long-run before-tax nominal annual rate of return on the Fund's assets used in the *Model* worksheet is 230 basis points, or 2.3%, higher than the Government nominal medium-term bond rate in any future year.

Like any assumption in the *Input* worksheet, this can be changed. However, it should be noted that whatever value is entered here is **added to the medium-term Government bond rate** i.e. entering 7% will not run the model at this rate of return, but rather at 7% plus whatever is the medium-term Government bond rate in that projected year.

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 calculations for contributions to the Fund use an **after-tax rate of return**, so this assumption affects more than just projected Fund tax payments).*

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 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 fiscal year, in billions of dollars, will be used by the model in place of the amount it would otherwise calculate. If the cell is left blank in that year, the model will calculate the value for that year. (Note: If it is desired that the model calculate the value for the year, then literally enter nothing in the cell in that year. **Do not enter** the value 0 (zero) as the model will use that zero value rather than apply the normal modelling logic).

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

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.

Since 2009/10 the Government has chosen to take a "capital contribution holiday" and hence the model currently applies a track of zero capital contributions until the latest predicted year for capital contributions to resume.

Forecasts of earnings and tax and other movements in reserves 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. Unless such a situation is desired to be modelled, this will normally consist of a track of zeroes. For this variable it does not matter whether the cells contain a zero or are left blank, as only non-zero entries impact on the modelling of the Fund.

GDP, NZS expenditure and Government medium-term bond rate

Capital contribution calculations use long-term projections of nominal GDP, aggregate net (of tax) NZS expenditure and the medium-term (currently 5-year) Government bond rate from the latest EFU.

Due to the long-run nature of these tracks, it is worth noting that copies from the latest EFU are kept in the *Defaults* worksheet if any or all of these tracks are altered.

Structural limit for annual capital contribution

The structural limit on the annual capital contribution can be entered, but by default it is **calculated** as nominal 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, Fund Balance and NZS to GDP worksheets

These worksheets are all graphs, generated from annual tracks in the *Model* worksheet or, in the case of the *NZS to GDP* graph, from annual tracks in the *NZS expense – History & Future* 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.

Model worksheet

Nominal GDP, Net NZS expenditure and Government nominal medium-term bond rate

These are all directly picked up, for each projected fiscal year, from the tracks for each variable in the *Input* worksheet.

Capital contribution in excess of net NZS expenditure, Earnings on assets, Tax on earnings, Other movements in reserves and One-off endowment

For each of these variables the formula checks whether or not a value has been entered for that fiscal year in the *Inputs* worksheet. If it has, then that value is picked up. Otherwise, the formula sets the cell to a blank entry.

Structural limit

This is directly picked up, for each fiscal year, from the track in the *Input* worksheet.

Before-tax nominal annual rate of return r on Fund assets

This is calculated, for each projected fiscal year, as the sum of the Government nominal medium-term bond rate in that year plus the selected increment to this bond rate from the *Input* worksheet. The Government nominal medium-term bond rate will vary over time, at least in the initial years of projections, while the increment added to the bond rate to produce the annual expected rate of return on the NZS Fund's assets, is a constant assumption.

After-tax nominal annual rate of return r^* on Fund assets

This is calculated, for each projected fiscal year, as:

Before-tax annual rate of return r x (1 - Tax rate on Fund earnings from *Input* worksheet)

After-tax nominal annual rate of return on Fund assets in form $1/(1+ r^*)$

This is calculated, for each projected fiscal year, from the after-tax annual rate of return r^* in exactly the form shown. The reason that this variable is calculated is because it is used in the Matrix to calculate discount rate for capital contributions (henceforth just referred to as the Matrix) and it is simpler to pick it up in this form rather than calculate it, along with a number of other quite complex calculations, in the Matrix.

After-tax in-year compound return v with fortnightly rests

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 $(1 + f)^{26} = 1 + r$

$$\rightarrow 1 + f = (1 + r)^{1/26}$$

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 j th 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:

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

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, except that, as the Fund's capital contribution calculations use the after-tax annual nominal rate of return, r^* , rather than the before-tax rate r , the formula in the *Model* worksheet uses r^* instead of r .

After-tax in-year compound return with fortnightly rests in form $(1 + v)$

This is calculated, for each projected fiscal year, from the after-tax in-year compound return with fortnightly rests v in exactly the form shown. The reason that this variable is calculated is because it is used in the Matrix and it is simpler to pick it up in this form there.

Required capital contribution plus net NZS expenditure as % of nominal GDP

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/>. In particular see the formula at the top of page 7 of this paper.

This variable, **whose calculation is the fundamental reason for the NZS Fund model**, is the required capital contribution to (or withdrawal from) the Fund, as a % of nominal GDP. The formula for any projected year j is:

$$\frac{\sum_{t=1}^H P_{j+t-1} (1 + v_{j+t-1}) \prod_{i=1}^t (1 + \mu_{i+j-1})^{-1} - B_{j-1}}{\sum_{t=1}^H G_{j+t-1} (1 + v_{j+t-1}) \prod_{i=1}^t (1 + \mu_{i+j-1})^{-1}}$$

where:

t is the fiscal year variable

H is the funding horizon (default is 40 years but this can be altered in the *Input* worksheet)

P is the aggregate net NZS expenditure in the subscribed fiscal year

v is the after-tax in-year compound return with fortnightly rests on Fund assets in the subscribed year

$(1+\mu)^{-1}$ is the after-tax nominal annual rate of return r^* on Fund assets in the form $1/(1+r^*)$ in the subscribed year

B is the closing NZS Fund balance in the previous fiscal year i.e. fiscal year $j - 1$

G is nominal GDP in the subscribed fiscal year

The product expression in the above equation is calculated, for each fiscal year, by the Matrix at the bottom of the *Model* worksheet.

Required capital contribution plus net NZS expenditure as nominal \$ value

This is calculated, for each projected fiscal year, as:

Required capital contribution + net NZS expenditure as % of nominal GDP x Nominal GDP

Required capital contribution as % of nominal GDP

This is calculated, for each projected fiscal year, as:

(Required capital contribution plus net NZS expenditure as nominal \$ value - Net NZS expenditure) ÷ Nominal GDP

Required capital contribution as nominal \$ value

This is calculated, for each projected fiscal year, as:

Required capital contribution as % of nominal GDP x Nominal GDP

Minimum contribution including net NZS expenditure

The formula checks, in each projected fiscal year, if that year is before the year nominated in the *Input* worksheet as the earliest fiscal year to draw upon the NZS Fund.

If that is true, the formula sets the minimum capital contribution to equal the net NZS expenditure in that year. Otherwise, i.e. the year is at or after that nominated as the earliest drawdown year, the formula sets the minimum capital contribution to zero.

Maximum contribution including net NZS expenditure

This is calculated, for each projected fiscal year, as:

Net NZS expenditure + Minimum {Capital contribution in excess of net NZS expenditure, Structural limit}

Effectively, in any projected fiscal year where a capital contribution amount has not been specified i.e. it has been left to the model to calculate, this will be calculated as the nominal GDP value in that year.

Actual capital contribution plus net NZS expenditure

The formula checks, in each projected fiscal year, if there is an entry for the Capital contribution in excess of net NZS expenditure in the same year in the *Input* worksheet.

If there is no entry, i.e. no set capital contribution has been specified for that year, the formula sets the actual capital contribution plus net NZS expenditure in that year to be the smaller of the:

- Bigger of the Required capital contribution plus net NZS expenditure as nominal \$ value and Minimum contribution including net NZS expenditure; and
- Maximum contribution including net NZS expenditure.

If there is an entry in the *Input* worksheet the formula sets the actual capital contribution plus net NZS expenditure in that year to equal Net NZS expenditure + Capital contribution in excess of net NZS expenditure.

This may all appear confusing but effectively it simply ensures that, in years where a value has been selected for the capital contribution, this variable cannot exceed that value plus net NZS expenditure for the year. Otherwise it will generally produce the capital contribution or withdrawal calculated by the model plus net NZS expenditure for the year.

less net NZS expenditure

In all projected years this is simply set to the negative of net NZS expenditure for that year.

Capital contribution

In the last actual historical year (shaded red) that forms the base from which the modelled projections launch, this is set to the final year value of Capital contribution from the Crown in the *History of NZS Fund* worksheet.

In all projected years this is calculated as the sum of Actual capital contribution plus net NZS expenditure and *less net NZS expenditure*, rounded to 3 decimal places i.e. to the nearest million dollars in nominal \$ terms.

This variable is, of course, the capital contribution to (or withdrawal from) the NZS Fund, in nominal \$, for that fiscal year.

Gross earnings on Fund assets

In the last actual historical year this is calculated as the sum of the final year values of the three variables Revenue, Gains/(losses) and the negative of *less Other expenses* in the *History of NZS Fund* worksheet.

The formula checks, in each projected fiscal year, if there is an entry for Earnings on assets forecast in the same year in the *Input* worksheet.

If there is no entry, i.e. no set earnings amount has been forecast for that year, the formula calculates the gross earnings by dividing the net (of tax) earnings on Fund assets (the variable two rows further down in the *Model* worksheet) by (1 – the assumption for the tax rate on Fund earnings chosen in the *Input* worksheet).

If there is an entry the formula sets gross earnings to Earnings on assets in this worksheet.

less Tax paid on earnings on Fund assets

In the last actual historical year this is set to the final year value of *less* Current tax expense in the *History of NZS Fund* worksheet.

The formula checks, in each projected fiscal year, if there is an entry for Tax forecast in the same year in the *Input* worksheet.

If there is no entry, i.e. no set tax payment has been forecast for that year, the formula calculates the tax payment by multiplying the gross earnings in the previous row by the assumption for the tax rate on Fund earnings chosen in the *Input* worksheet.

If there is an entry the formula sets this variable to Tax on earnings in this worksheet.

Net earnings on Fund assets

In the last actual historical year this is calculated as Gross earnings on Fund assets – *less* Tax paid on earnings on Fund assets.

The formula checks, in each projected fiscal year, if there is an entry for Earnings on assets forecast in the same year in the *Input* worksheet.

If there is no entry the formula calculates the net earnings by summing together the multiple of the previous fiscal year's Closing Fund balance by the After-tax nominal annual rate of return r^* on Fund assets gross earnings and the multiple of the same fiscal year's Capital contribution by the After-tax in-year compound return v with fortnightly rests.

If there is an entry the formula calculates this variable in exactly the same way it is calculated in the last actual historical year.

One-off endowment

Set to One-off endowment in this worksheet.

Other movements in reserves

In the last actual historical year this is set to the final year value of Other movements in reserves in the *History of NZS Fund* worksheet.

The formula checks, in each projected fiscal year, if there is an entry for Other movements in reserves in the same year in the *Input* worksheet.

If there is no entry, i.e. no value for this variable has been forecast for that year, the formula calculates the other movements in reserves by multiplying the previous year's value by the annual growth in the Gross earnings on Fund assets.

If there is an entry the formula sets this variable to Other movements in reserves in this worksheet.

Closing Fund balance

In the last actual historical year this is set to the final year value of Closing net worth in the *History of NZS Fund* worksheet.

In each projected fiscal year this is calculated as the sum of the previous year's Closing Fund balance and the same fiscal year's values of Capital contribution, Net earnings on Fund assets, One-off endowment and Other movements in reserves.

Net NZS expenditure as % of nominal GDP, Actual capital contribution plus net NZS expenditure as % of nominal GDP, Capital contribution as % of nominal GDP, Gross

earnings on Fund assets as % of nominal GDP, Tax paid on earnings on Fund assets as % of nominal GDP, Net earnings on Fund assets as % of nominal GDP and Closing Fund balance as % of nominal GDP

All of these variables are calculated, in each projected year, as their nominal value, from the section in this worksheet immediately above this one (except for Net NZS expenditure, which is found at the top of the worksheet), by nominal GDP in the same year.

Matrix to calculate discount rate for capital contributions

This matrix is used to produce the product terms $\prod_{i=1}^t (1 + \mu_{i+j-1})^{-1}$ in the calculation of the Required capital contribution plus net NZS expenditure as % of nominal GDP variable. It doesn't really need to be a 97 x 97 matrix, as rows become the same repeating sequence once the Government medium-term bond rate is assumed to become constant, and hence so is the After-tax nominal annual rate of return r^* on Fund assets. However once the formula to calculate the matrix terms is set up, it is easy to drag it out. Hence this size matrix covers the period out to where the long-run GDP, net NZS expenditure and Government medium-term bond tracks end.

The matrix entry offset functions ensure that, in any projected year, the product term shown above calculates terms from After-tax nominal annual rate of return on Fund assets in form $1/(1+r^*)$, starting in that year and extending out over the number of years into the projection that that fiscal year occurs.

An example will help to explain. Take the entry in the 4th row and 5th column of this matrix. If you check you will find it equals the product of the five $1/(1+r^*)$ terms, beginning in the fourth projected year and ending with the eighth projected year term.

When it is picked up in the overall calculation of the Required capital contribution plus net NZS expenditure as % of nominal GDP variable for the fourth projected year, this product of five terms will multiply the eighth projected year value of Net NZS expenditure (if in the numerator) or nominal GDP (if in the denominator) multiplied by the eighth projected year value of After-tax in-year compound return with fortnightly rests in form $1+v$.