The Discount rate for the Economic Evaluation Manual 2013

NZ Transport Agency EEM Technical Paper

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Keywords: BCR, benefits, cost benefit, discount rate, land transport investment,
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Abbreviations and acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>BCR</td>
<td>Benefit-cost ratio</td>
</tr>
<tr>
<td>CAPM</td>
<td>Capital asset pricing model</td>
</tr>
<tr>
<td>CBA</td>
<td>Cost-benefit analysis</td>
</tr>
<tr>
<td>EEM</td>
<td>Economic evaluation manual (NZTA publication)</td>
</tr>
<tr>
<td>LTMA</td>
<td>Land Transport Management Act</td>
</tr>
<tr>
<td>ERP</td>
<td>Equity risk premium</td>
</tr>
<tr>
<td>NPV</td>
<td>Net present value</td>
</tr>
<tr>
<td>NZTA</td>
<td>NZ Transport Agency</td>
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<tr>
<td>PV</td>
<td>Present value</td>
</tr>
<tr>
<td>SOC</td>
<td>Social opportunity cost</td>
</tr>
<tr>
<td>STPR</td>
<td>Social time preference rate</td>
</tr>
<tr>
<td>WACC</td>
<td>Weighted average cost of capital</td>
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Executive summary

The NZTA Economic evaluation manual (EEM) utilises Social cost-benefit analysis, or CBA for short, as a method of evaluating the added benefits and costs over time to the whole of society from an initiative or set of initiatives. The EEM seeks to assess the overall benefit to society and to guide the prioritisation of the initiatives and others by evaluating the pros and cons of each action for all of society’s stakeholders relative to the status quo.

Effects are expressed in monetary terms, even though they may not involve flows of cash or even have market prices, and they are measured by comparing the results of the initiative against what would probably have happened if the initiative did not occur (the counterfactual).

Time is a key consideration: competing initiatives usually have different, if not substantially different, profiles of costs and benefits over time. The evaluator must trade greater social benefits in the future off against more modest benefits that occur earlier. The public sector discount rate, through a process of discounting, is the parameter that governs this trade-off of effects across time by finding the present value of future costs and benefits.

In the absence of any taxes or other distortions, the selection of a discount rate is conceptually straightforward. In this case the marginal return on capital in the private sector and the rate of time preference (or the consumer interest rate) would be equal, and either rate would be appropriate as the public sector discount rate.

The reality is not as straightforward. There is a range of taxes and other issues which drive wedges between the marginal rate of return on capital and the return to deferring consumption. Much of the debate in the literature centres on how to resolve this paradox.

The two fundamental concepts are the cost of capital and time preference. A discount rate is intended to reflect the opportunity cost of capital used in the project and simultaneously reflect the preference for current, over deferred, consumption.

This creates a problem of trying to address more than one goal with a single instrument. Much of the literature in discounting boils down to how to resolve this problem. The matter is compounded by attempts to add further goals.

Various approaches have been proposed to combine the two fundamental concepts. A simple scheme involves using the weighted average of the two rates. An alternative approach endeavours to independently assess the social rate of time preference and subsequently allow for the opportunity cost of funds by applying an estimate of the shadow price of capital.

Many of the elements needed to apply the different approaches are not directly observable. For the weighted average approach, the challenge lies in the selection of the weights which are not directly observable and may arguably differ for each project depending on the type of financing. Estimates of the social rate of time preference and the shadow price of capital require indirect methods and raise conceptual problems.

An alternative approach is to anchor the discount rate to an observable rate within a Social Opportunity Cost (SOC) framework. To minimise the need for estimation, it is desirable to anchor the discount rate to an observable market rate. The long-term government bond rate serves as such an anchor. The government bond rate reflects the cost of capital facing New Zealand in international markets.

The Capital Asset Pricing Model (CAPM) methodology utilises bond rates and other observable information to determine a theoretically appropriate rate of return reflecting the opportunity cost of funding, making allowances for inflation, taxation and risk. The CAPM methodology has been used by

1Note: This summary is informed by Anthony Casey, Wayne Heerdegen and Grant M Scobie (2007) “The Public Sector Discount Rate: Review and Recommendations,” mimeo, New Zealand Treasury
the Treasury for establishing the public sector cost of capital and the discount rate for public sector projects.

Risk must be assessed in a portfolio context. People are typically risk adverse; that is they would choose a certain outcome over a risky outcome with the same expected value. The relevant concept of risk is not the inherent riskiness of a particular project per se, but rather the change in the overall risk associated with a portfolio of projects resulting from the inclusion of the project under question.

The same framework for assessing risk in the private sector can be applied to the public sector. Modern finance theory can be invoked to handle risk. Modern finance theory offers a way to adjust for risk, based on the observed premium about the risk free rate in equity markets. This is modified by the extent to which the expected return moves with the market as a whole (the “beta” coefficient).

Adjusting for risk inevitably involves judgement. Not all projects will have returns that vary to the same extent with “the market”. Some classes of projects will tend to vary little with overall economic activity. They would be assigned to a lower adjustment for risk. In the cases where there is a very low degree of covariance, the risk adjustment drops away and the discount rate becomes the base risk free rate.

After allowing for taxation and risk, the remaining factors are inflation (2.5%), ERP (3.6% - 7%) and asset beta (0.2 - 0.4). From these factors a discount rate for the evaluation of transport projects by the NZTA EEM of 6% has been estimated.

Caution required

Benefit cost analysis is an important tool but not a substitute for judgement. The use of cost-benefit analyses is important in guiding the efficient allocation of public investment. However it is not a panacea, and considered judgement and thorough documentation of the assumptions is important.

Sensitivity analysis is recommended, not just on the discount rate but also on the benefits and costs of the proposed project. Discount rates are fundamentally a mechanism to connect the future with the present. To the extent that the future is uncertain and perceptions of future developments are reflected in today’s expectations, then it is unreasonable to expect that there would ever be a single approach or a single discount rate that would meet with universal acceptance. Careful professional judgement, sensitivity analysis and transparent documentation available for public scrutiny are all required.
Abstract

This paper reviews the methodology for the calculation of the Discount rate for Cost Benefit Analysis in the NZTA Economic Evaluation Manual, utilising a Social Opportunity Cost framework based on the Capital Asset Pricing Model (CAPM). This methodology is consistent with the New Zealand Treasury guidance on Public Sector Discount Rates for Cost Benefit Analysis\(^2\) whilst the resulting recommended discount rate is different due to primarily a differing framework for determining the asset beta for transport.

Assumptions used by the CAPM; tax, inflation, equity risk premium (ERP), risk free rate (RFR) and asset beta (\(\beta_a\)) are reviewed and, where appropriate, updated to reflect current economic literature and the latest market values. As the ERP and asset beta are not directly observable for the NZTA, these assumptions are considered in detail identifying ranges of possible assumptions based on different methodologies for the ERP and proxies for the asset beta.

A baseline rate of 6\% has been estimated. Scenario testing at 4\% and 8\% is recommended reflecting the range of rates obtainable under different plausible assumptions for the ERP and asset beta. The rate is based on an average ERP of 7\% and asset beta of 0.4.


http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/discountrates
Introduction

The Discount Rate

The NZTA Economic evaluation manual (EEM) utilises Social cost-benefit analysis, or CBA for short, as a method of evaluating the added benefits and costs over time to the whole of society from an initiative or set of initiatives. The EEM seeks to assess the overall benefit to society and to guide the prioritisation of the initiatives and others by evaluating the pros and cons of each action for all of society’s stakeholders relative to the status quo.

The EEM identifies that the community places a higher value on benefits and costs that occur in the near future, compared to those that occur at a later date. In the evaluation of proposals a mechanism is need to identify the rate at which those values change over time. At the same time resources that will be expended in the activity under consideration cannot be utilised for other activity, therefore a discount rate is used to reflect the opportunity cost of capital used in the project and simultaneously reflect the preference for current, over deferred, consumption.

There are two main approaches for establishing the discount rate:

a) The Social Rate of Time Preference – which is equal to the marginal rate of substitution between consumption in one period and the next period. In other words it is the rate of return needed to make society indifferent between consuming x today and x(1+r) in the next period. In an efficient allocation (with no distortions or other market imperfections) all individuals have the same marginal rate of time preference; and

b) The Social Opportunity Cost – which considers the amount of other activity which has to be forgone because resources are displaced for the activity under consideration.

These two approaches to establishing the discount rate in New Zealand are discussed by Young (2002)\(^3\) and Parker (2002)\(^4\). Parker also discusses the implications of changes in the discount rate on transport investments. Further useful discussion and information on discount rate methodologies, issues with the choice of discount rate in different circumstances, treatment of risk, observability of assumptions, and relationship of discount rate and cost benefit analysis is provided by Scobie (2007)\(^5\), Grimes (2010)\(^6\), in addition to the works of Parker and Young.

This paper reviews the calculation of the discount rate for Cost Benefit Analysis in the NZTA Economic Evaluation Manual, utilising the Social Opportunity Cost framework based on the Capital Asset Pricing Model (CAPM). The CAPM provides information on the opportunity cost of resources forgone by establishing the appropriate rate of return expected from an activity. This methodology is currently utilised by the NZ Treasury for establishing the cost of capital for public sector entities and for the discount rate for government investment.

Capital Asset Pricing Model

The Capital Asset Pricing Model (CAPM) provides an assessment of the cost of equity utilising bond rates and other observable information to determine a theoretically appropriate rate of return reflecting the opportunity cost of funding (discount rate), making allowances for inflation, taxation and

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risk. The CAPM relates the cost of equity of a particular company to its exposure to systematic or non-diversifiable equity market risk. Compensation for non-systematic risk is not required because this risk can be eliminated through diversification of assets.

**Calculation of the Cost of Equity**

Estimating the cost of equity is key to the CAPM. The cost of equity is the return required by investing equity in a project. It can be calculated as:

\[ \text{The risk free rate} + (\text{beta} \times \text{ERP}) \]

Where

- The risk free rate measures the return required by investors from investing in a security that is judged to be relatively risk-free. It is a generic parameter and not specific to the project being assessed. There is general consensus that long term government bonds represent the risk free rate;
- The beta provides a measure of the risk of the asset relative to the market as a whole. It is specific to the company being assessed. Since the NZTA is not publicly listed on the equity market the asset beta parameter needs to be estimated based on comparable companies that are likely to face similar business risks;
- The ERP (Equity Risk Premium) is estimated as the excess return on the market portfolio over the risk free rate. It is a generic parameter, and therefore not specific to the company being addressed.

Tax and Inflation needs to be taken into account by incorporation into the cost of capital. Tax can be addressed by amending the cost of equity calculation, to include the corporate tax rate and effective tax rate. This amends the cost of equity equation to:

\[ \text{The risk free rate} \times \text{corporate tax} + (\text{equity risk premium} \times \text{asset beta}) \text{ divided by effective tax rate.} \]

This can be stated as:

\[ \frac{[\text{RFR} \times (1-\text{Tc}) + (\text{Ep} \times \beta_a)]}{(1-\text{Te})} \]

And generates a nominal (not inflation adjusted) weighted average cost of capital (WACCn). To account for the effect of inflation and generate a real (inflation adjusted) cost of equity, inflation is specifically accounted for through the following equation:

\[ \frac{((1+WACCn)/(1+i))}{1} \]

The whole formula is:

\[ \text{WACC (real)} \times (1-\text{Tc}) + (\text{Ep} \times \beta_a) \]

Where

\[ \text{WACCn} = \frac{[\text{RFR} \times (1-\text{Tc}) + (\text{Ep} \times \beta_a)]}{(1-\text{Te})} \]

**Key**

- Tc (corporate tax rate)
- Te (effective tax rate)
- Ep (equity risk premium)
- RFR (risk free rate)
- \( \beta_a \) (asset beta)
- i (inflation rate)

This methodology is used by the Treasury in the Treasury’s guide to Public Sector Discount Rates for Cost Benefit Analysis.
The NZ Transport Agency discount rate - 2013

This section reviews the assumptions for the discount rate calculation for NZTA. Particular attention is given to the two factors that are not readily observable, the Equity Risk Premium (ERP) and asset beta ($\beta_a$), by establishing a range of possible ERP’s and a framework for establishing the appropriate asset class for NZTA and then a range of proxy beta to estimate the NZTA asset beta.

Tax and Inflation

For the NZTA discount rate values for corporate and effective tax rate are based on current tax rules:
Corporate tax rate – 28%
Effective tax rate – 24%

Inflation is based on 5 year average CPI, noting that the rate of inflation over the medium term is within the Reserve Bank of New Zealand (RBNZ) policy target agreement, where the policy target shall be to keep future CPI inflation outcomes between 1 per cent and 3 percent on average over the medium term, with a focus on keeping future average inflation near the 2 per cent target midpoint.
For the NZTA discount the current 5 year average is 2.5%

Therefore the recommended values for corporate tax, effective tax and inflation are:
Tc (corporate tax rate)   28%
Te (effective tax rate)  24%
I (inflation rate)   2.5

Equity Risk Premium

The Equity Risk Premium (ERP – also referred to as Market Equity Risk Premium) is a parameter appearing in all versions of the CAPM. The ERP represents the expected rate of return on stocks in excess of the risk-free rate (ten year government bond). The ERP is a key component in deriving discount rates. For decades, the ERP concept has been debated by academics and practitioners because no method is universally accepted or used for deriving the ERP.

There are various methods to estimate the ERP and each has its own strengths and weaknesses. They also generate a wide range of results, some of which are summarised in figure 1 below:

Figure 1: Summary of ERP estimates

<table>
<thead>
<tr>
<th>Method</th>
<th>ERP Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMS Geometric mean</td>
<td>3.6%</td>
</tr>
<tr>
<td>DMS Historical Arithmetric mean</td>
<td>5.2%</td>
</tr>
<tr>
<td>Lally &amp; Marsden TAMRP</td>
<td>7.0%</td>
</tr>
<tr>
<td>McCulloch Range 3-5%</td>
<td>4.0%</td>
</tr>
<tr>
<td>Lally &amp; Marsden Siegel Methodology</td>
<td>5.9%</td>
</tr>
<tr>
<td>Fernandez Survey</td>
<td>6.2%</td>
</tr>
<tr>
<td>Not included in Figure 1 is an Implied ERP estimate.</td>
<td></td>
</tr>
</tbody>
</table>

Sources:
- Geometric mean - Dimson, Marsh Staeon Credit Suisse Global Investment Returns Sourcebook, 2012, Credit Suisse/ London Business School;
- Arithmetic mean - Dimson, Marsh Staeon Credit Suisse Global Investment Returns Sourcebook, 2012, Credit Suisse/ London Business School;
- Lally and Marsden Siegel Methodology - Lally, M and Marsden, A., (2005) Estimating the Market Risk Premium in New Zealand through the Siegel Methodology; and
The ERP is typically estimated based on the average historical return of equity securities in excess of the risk-free rate. The Equity Risk Premium (ERP) is an expected return, which is not directly observable and so must be estimated. This is because:

- The ERP is an ex ante (forward looking) concept and reflects expectations; and
- The market portfolio itself cannot be observed as market values for many assets are not known, so it requires the use of a proxy (e.g. returns on an index of listed equities).

Therefore, literature on the equity risk premium largely revolves around establishing a methodology for estimation of the rate. There are three broad approaches used to estimate equity risk premiums:

- One is to survey investors, managers and academics to get a sense of their expectations about equity return in the future.
- The second is to assess the returns earned in the past on equities relative to riskless investments and use the historical premium as the expectation.
- The third, called “implied premiums”, is to attempt to estimate a forward looking premium based on the market rates or prices on traded assets today.

These different approaches result in different values for the equity risk premium.

**Historical returns method**

The most widely used approach to estimating equity risk premium is the historical premium approach, where the actual returns earned on shares over a long time period is estimated and compared to the actual returns earned on a default-free (government bond). The difference on an annual basis, between the two returns, is computed and represents the historical risk premium.

\[
ERP = \text{average annual equity index return} - \text{average return on government bonds}
\]

Depending on the series used, different equity premiums [or should this be “ERPs”?] can be generated. The reasons for divergences are; different time periods for estimation; differences in risk free rates (use of short or long term bonds) and market indices and; differences in the way returns are averaged over time.

There are two averaging approaches. The first is arithmetic average measuring the simple average of the series of annual returns. The second is geometric average which looks at the compounded return.

The choice of arithmetic or geometric averaging methods can lead to significant differences in estimates. For example, if $100 grows to $110 in one year and then drops back to $100 the next, the arithmetic average annual return is \([+10.0\% - 9.1\%]/2\), or 0.5%. The geometric mean will be 0% which is the compounded annual return the investor actually earned.

The value of the arithmetic mean is that it represents an investor’s expected return at any given point in time, whereas the geometric mean reflects the asset return investors should expect over long horizons.

The most commonly referenced sources for international historical averages are;

- Dimson, Marsh and Staunton;
- Ibbotson;
- Duff and Phelps;
- Barclays Equity Gilt Study

All of these sources have limitations. The Ibbotson series is one of the first sources of long term historical equity premiums developed, however the series is focused on the United States market using the Standard and Poor 500 index starting from 1926. The Duff and Phelps Risk report and the Barclays Equity Gilt Study have differing time periods and differing methodologies with longer (20 year) or shorter (3-5 year) bond rates used. The Dimson, Marsh and Staunton [“series”?] extends over a longer time period from 1900 to 2012 and currently extends to 19 markets including New Zealand.
The reliability of estimates based on historical averages relies on the quality and availability of the underlying data. If only a relatively short time series is available, the resulting ERP estimates are likely to be statistically imprecise. However, adopting too long a series, as an attempt to improve the precision of the ERP estimates, increases the possibility of including data from periods that are less relevant to the current period. In a changing economic environment a historical ERP may be misleading as it does not capture the direction of changes in the market i.e., lower returns in future years and higher returns to bonds.

Damodaran (2012) provides information on the standard errors in Historical Risk Premiums.10

<table>
<thead>
<tr>
<th>Estimation Period</th>
<th>Standard Error of Risk Premium Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years</td>
<td>20% / √5 = 8.94%</td>
</tr>
<tr>
<td>10 years</td>
<td>20% / √10 = 6.32%</td>
</tr>
<tr>
<td>25 years</td>
<td>20% / √25 = 4.00%</td>
</tr>
<tr>
<td>50 years</td>
<td>20% / √50 = 2.83%</td>
</tr>
<tr>
<td>80 years</td>
<td>20% / √80 = 2.23%</td>
</tr>
</tbody>
</table>

New Zealand Equity Risk Premium

For New Zealand, Martin Lally and Alastair Marsden have provided a historic equity risk premium based for New Zealand based on data from 1931 – 2002.11 PWC produced a report on the New Zealand Equity Market Risk Premium establishing a risk premium of 7.5% covering the period 1925 to 200212. The Dimson, Marsh and Staunton estimate is published annually in the Credit Suisse Global Investment Returns Sourcebook, providing both a geometric mean and arithmetic mean. Table 1 below sets out the Dimson, Marsh and Staunton historical risk premiums.

Table 1 : Equity Risk premium for 19 Markets 2012
Source: Dimson Marsh and Staunton, Credit Suisse Global Investment Returns Sourcebook, 2012, Credit Suisse/ London Business School.13

<table>
<thead>
<tr>
<th>Country</th>
<th>Stocks minus Short term Governments Bills</th>
<th>Stocks minus Long term Governments Bonds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geometric Mean</td>
<td>Arithmetic Mean</td>
</tr>
<tr>
<td>Australia</td>
<td>6.50%</td>
<td>8.00%</td>
</tr>
<tr>
<td>Belgium</td>
<td>2.80%</td>
<td>5.40%</td>
</tr>
<tr>
<td>Canada</td>
<td>4.10%</td>
<td>5.50%</td>
</tr>
<tr>
<td>Denmark</td>
<td>2.60%</td>
<td>4.40%</td>
</tr>
<tr>
<td>Finland</td>
<td>5.50%</td>
<td>9.20%</td>
</tr>
<tr>
<td>France</td>
<td>5.90%</td>
<td>8.50%</td>
</tr>
<tr>
<td>Germany</td>
<td>5.70%</td>
<td>9.50%</td>
</tr>
<tr>
<td>Ireland</td>
<td>3.00%</td>
<td>5.30%</td>
</tr>
<tr>
<td>Italy</td>
<td>5.50%</td>
<td>9.50%</td>
</tr>
<tr>
<td>Japan</td>
<td>5.60%</td>
<td>8.80%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>4.10%</td>
<td>6.40%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>4.00%</td>
<td>5.60%</td>
</tr>
<tr>
<td>Norway</td>
<td>2.90%</td>
<td>5.70%</td>
</tr>
<tr>
<td>South Africa</td>
<td>6.20%</td>
<td>8.20%</td>
</tr>
</tbody>
</table>

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14 Summary data is accessible at the Credit Suisse website.
The Geometric and Arithmetic mean based on long term government bonds (10 year) risk premiums of 3.6% and 5.2% Risk Premium average of 6.2% are used as a scenario for estimating the NZTA Discount rate.

Survey Premiums

If equity risk premium is what investors demand for investing in risky assets today, a survey of investors should yield what they require as expected returns. Whilst there are numerous investors in shares, surveys generally focus on institutional investors/investment professionals, Chief Financial Officers (Managers) and Academics.

The largest published survey of Equity Risk Premium is by Fernandez (2011) providing the market risk premium used in 56 countries in 2011'. Based on 1,611/1,609/1,901/1,107 specific responses to the question from professors/analysts/non-financial companies/financial companies, respectively, around the world, they find that:

- Weighting each country equally, the average (median) worldwide equity risk premium is 7.8% (7.8%). Weighting each specific response equally, with 36% of all specific responses for the U.S., the average (median) worldwide equity risk premium is 6.3% (6.0%),
- Where comparisons are possible, 68% (71%) of average (median) country equity risk premium estimates for 2012 are higher than those for 2011.
- Median equity risk premium estimates range from 5.0% for Germany, Denmark, the UK and Japan to nearly 20% for Iran (see the chart below). The median estimate for the U.S. is 5.4%.
- Across countries, professors and financial companies (analysts) tend to provide slightly higher (or lower) equity risk premium estimates than the overall sample.
- The top four cited sources for the equity risk premium among all respondents, in descending order, are: Damodaran, Morningstar/Ibbotson, internal estimates and historical data.

The New Zealand Market Equity Risk Premium average is 6.2% with a median of 6.0 and std dev of 1.1. Min is 2.0 Max 9.0, Q1 5.5 and Q3 7.0. Based on 40 answers to survey.

The range of estimates internationally, and for New Zealand specifically, is substantial. The New Zealand Market Equity Risk Premium average of 6.2% is used as a scenario for estimating the NZTA Discount rate.

Implied Premium

An implied premium is a forward looking (ex ante) approach to estimating the ERP. Two approaches that have been used to develop forward looking estimates are:

- The dividend growth model (in which price is the expected present value of future dividends) to obtain the implied return as the discount factor, and;
- The residual income model, which directly uses analysts’ earnings forecasts.

An implied premium utilises the Discounted Cash Flow (DCF) model to generate a forward-looking estimate of the premium using either current equity prices or risk premiums in non-equity markets. Implied premiums require estimation of future growth rates, information on dividend yield and the real bond yield. Assumptions around growth rates and future dividend years raises question about the

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value of implied Equity Premium beyond a point in time estimate. However, implied premium can provide a reference point to consider the reasonableness of other ERP estimates.

An implied premium has not been estimated for the NZTA Discount Rate, although this is a methodology that should be looked at further to provide assurance on other estimates.

NZTA Asset Beta

The asset beta is a measure of a business’s sensitivity to non-diversifiable risk. The beta ($\beta$) is a measure of the sensitivity of an asset’s return to that of the market portfolio. A beta of one means that the expected return of the investment always moves with the market as a whole; a beta of zero means that the expected return of the investment is independent of the market. A beta of zero implies the risk premium is also zero.

The weighted average beta of all stocks in a market equals one (same as the market beta).

The asset beta is sometimes referred to as financial elasticity or correlated relative volatility. In financial theory it is defined as a measure of the sensitivity of an asset’s returns to market returns. In regulatory economics an asset beta generally refers to a measure of the sensitivity of an individual business’s returns to market returns, also known as the business’s sensitivity to non-diversifiable risk (systematic risk or market risk).

The asset beta is the most common measure of non-diversifiable risk associated with a business. The asset beta is a number that describes the relationship a business’s returns have with the returns of the financial market as a whole. It measures the extent to which the returns on a security move with the market as a whole and is defined as follows:

$$\beta_i = \frac{\text{covariance}(r_{it}, r_{mt})}{\text{variance}(r_{mt})}$$

Where:
- $\beta_i$ = beta value for security $i$
- $r_{it}$ = return on security $i$
- $r_{mt}$ = return on market portfolio

An empirical estimate of a business’s beta requires data relating to the business’s returns (inclusive of changes in the market value of the underlying assets) and returns for whatever index is being used. These returns can be over any period (e.g. weekly, monthly). The implication of these requirements is that a business will need to be listed if its beta is to be directly calculated\(^{15}\).

As NZTA is not a publicly listed entity, and as there are few network transport entities worldwide, an estimate of the asset beta cannot be obtained directly. Therefore, the asset beta has been estimated using an indirect approach, based on:

- establishing the asset class for NZTA activity;
- assessing the business risks faced by NZTA, and then;
- identifying as many companies as possible (nationally and internationally) that have comparable characteristics, of which key characteristics are the business mix and regulatory framework.

This provides a proxy asset beta that can be used for estimation.

Asset Class for NZTA

*About NZTA*

NZTA has four core business functions\(^{16}\):
- Planning the land transport networks
- Investment in land transport

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\(^{15}\) Page 4, Frontier Economics (2010). The cross sectoral application of equity betas: energy to water

• Managing the state highway network, and
• Providing access to and use of the land transport system

The State Highway network is the dominant asset of NZTA comprising 11,000 kilometres of road, NZTA also invests significantly in the linking 83,000 kilometres of local road. NZTA is also investor in public transport (rail and bus services) provided by regional councils.

NZTA is established under the Land Transport Management Act 2003. The role of NZTA is to deliver the Crowns outcomes for land transport as set out in the Government Policy Statement. This involves the planning and funding of land transport and the enforcement of laws, regulations and rules, and the collection of revenue. It also involves ensuring New Zealanders have access to land transport, including through building, operating and maintaining land transport systems.

The Road Network

NZTA has responsibility for the capital and operating programmes for the State Highway network. This includes the building of new roads and associated bridges, tunnels, via-ducts and culverts. It also involves responding to network faults and carrying out planned maintenance and refurbishment of these assets.

NZTA as an infrastructure entity

Infrastructure is sometimes defined as the fixed, long-lived structures that facilitate the production of goods and services, both physical and institutional. More specifically, infrastructure refers to physical network infrastructure, principally transport, water and energy and communications.

The New Zealand National Infrastructure Plan 2010\textsuperscript{17}, which includes NZTA activity, avoids offering a rigid definition of infrastructure but provides some parameters within which it has been developed.

The OECD uses a simple and general definition for infrastructure as the system of public works in a country, state or region, including roads, utility lines and public buildings. A standard dictionary's definition is:

"The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons. (American Heritage Dictionary)."

Recent literature considers whether infrastructure is an asset class of its own or whether it is just a particular sector of the economy. There is no clear decision one way or the other, however it is worthwhile to note that the perspective of investment and financial advisors is that infrastructure is ‘different’ from other assets.

Investment in infrastructure assets in recent years has given some guidance on what comparator companies might look like and there key characteristics. A definition of infrastructure is provided by Ibbotson\textsuperscript{18}:

"Infrastructure is the physical assets, facilities, and systems that enable society to function. It includes the transportation (roads, bridges, tunnels, airports, railroads, ports, etc.), energy and utilities (power generation, fuels, water systems, etc.), communication (line-based networks, air-based networks), and social (schools, hospitals, prisons, other public buildings) assets of society. These are long-lived, real assets that are costly and time-consuming to replace, often without immediate substitutes that typically generate relatively stable cash flows that increase with inflation."

Infrastructure assets typically show one or more of the following stylized economic characteristics:
• high barriers to entry

• economies of scale (e.g. high fixed, low variable costs)
• inelastic demand for services (giving pricing power)
• low operating cost and high target operating margins
• long duration (e.g. concessions of 25 years, leases up to 99 years).

From these stylized characteristics, the investment industry deduces a number of favourable investment characteristics of infrastructure assets:
• stable and predictable cash flows
• long term income streams
• often inflation-linked (helping with liability-matching)
• in some countries, tax-effective returns insensitive to the fluctuations in business, interest rates, stock markets
• relatively low default rates
• low correlations with other assets classes (offering diversification potential)
• socially responsible investing (SRI) (providing public goods essential to society)8.

Recent literature has considered whether the characteristics of infrastructure (such as transport networks, whether rail or roading) means that it is a separate financial asset class distinct from other assets. There is a view that infrastructure assets are "low risk" and may have a distinctive risk/return profile which includes low return volatility. This low return volatility being due to some infrastructure services being considered essential services (e.g., water, electricity, network roads/rail) from which income is stable. Therefore investments in infrastructure are characterised by low volatility in comparison to other equities.

There is no formal evidence that all infrastructure shares these same characteristics, with available studies using limited data or being single estimates. A review of infrastructure risk was set out by Rothballer and Kaserer (2011) 19 identifying that, from available information, infrastructure appears to have low market risk yet significant idiosyncratic risk. It appears that there is a differentiated risk profile for each sector within infrastructure which is driven by regulation, competition, innovation, operating complexity and price risk.

Therefore using infrastructure as an asset class per se will not provide a suitable set of comparators to provide a proxy for the NZTA asset beta. However, by reviewing the perspective of the financial market of infrastructure, we now have a set of characteristics that provide a basis for establishing what entities might provide a suitable comparator proxy for NZTA.

These economic and financial characteristics can be used to establish a risk-return profile for infrastructure assets in relation to other assets. Figure 2 below adapted from Deloitte highlights this profile.

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This stylised profile broadly matches the profile of the sector beta for US assets that could be considered infrastructure assets. This is illustrated in figure 3 below.

**Figure 3: US Infrastructure assets sector beta profile.**
Source Damodaran (2013), Value Line

The Infrastructure beta profile represented above is similar in the United Kingdom, Canada, Australia and New Zealand.

**NZTA characteristics and underlying business risks**

Key characteristics of NZTA are that it is a monopoly network provider of roading, directly in the case of the State Highway network and in partnership with local government for the local roading network. Additionally NZTA is an investment partner of passenger transport services in conjunction with local government, these investments are in both bus and rail services.
NZTA therefore maps well to the stylized economic characteristics of an infrastructure asset with barriers to entry (monopoly), economies of scale, inelastic demand, long duration and relatively low operating costs. This generates stable and predictable cash flows, long term income streams, a low default rate and low correlation with other asset classes.

From these characteristics the business risks faced by NZTA can be separated between specific risks and systematic risks.

**Specific Risks**
Specific risks are those risks that only apply to a particular asset class and which are not correlated with the overall returns of the market portfolio. As these risks can be diversified by investors they do not affect a company's cost of capital. An example of a specific risk affecting the NZTA is the effect of legislation – e.g. energy efficiency policies. These may affect demand for energy or subsidise particular types of energy.

**Systematic Risks**
Systematic risk, also known as market or non-diversifiable risk, is risk that is characteristic of an entire market. As it cannot be diversified away by investors, the extent of the systematic risk affects the cost of capital. Risks with a systematic element affecting NZTA as a network provider include: Demand Volatility; Changes in input costs; Interest rate movements; Changes in inflation. Additional factors effecting risk exposure are: Operating leverage and the Regulatory framework.

These risk factors and their effect on an NZTA beta are reviewed in table 2 below.

**Table 2: NZTA risk factors**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on asset beta</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry, i.e. the nature of the product or service.</td>
<td>Firms producing products with low income elasticity of demand (e.g., necessities) should have lower sensitivity to real GNP shocks than firms producing products with high income elasticity of demand (luxuries), because demand for their product will be less sensitive to real GNP shocks.</td>
<td>NZTA is provider of critical infrastructure (necessities).</td>
</tr>
<tr>
<td>Nature of the customer</td>
<td>This has two aspects. The first is customer split between public and private sector demand. Firms producing a product whose demand arises from the public sector should have a lower sensitivity to GNP shocks. The second aspect is residency, with demand from external (foreign) customers having a lower sensitivity to GNP shocks. A third aspect is the personal/business mix.</td>
<td>Note: Like utilities and other infrastructure assets (except ports) there is effectively no external customers for transport.</td>
</tr>
<tr>
<td>Pricing structure</td>
<td>Revenues comprising both fixed and variable components should have a lower sensitivity to GNP shocks.</td>
<td>Two parts: annual licensing fee fuel based excise/road user charges</td>
</tr>
<tr>
<td>Duration of contract prices with supplies and customers</td>
<td>Can the business increase/decrease prices quickly in response to increased/decreased demand.</td>
<td>Prime purpose of Transport Fuel Excise Duty, Road User Charges, Motor Vehicle Register licence fee is to recover costs and provide a reasonable price signal of the long term costs of road use.</td>
</tr>
<tr>
<td>Presence of price or rate of return</td>
<td>Firms subject to rate of return regulation could have a lower sensitivity to GNP shocks, because the regulatory</td>
<td>As a Crown entity (non SOE) NZTA</td>
</tr>
</tbody>
</table>

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20 Informed by framework set out in Lally M. 2005, ‘The Equity Beta for ETSA Utilities’
<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on asset beta</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>regulation</td>
<td>process is geared towards achieving a fixed rate of return.</td>
<td>is directly regulated.</td>
</tr>
<tr>
<td>Degree of monopoly power, i.e., the price elasticity of demand for the firms output.</td>
<td>The price elasticity of demand for the firms output. If monopoly power affects beta, then the effect of any countervailing power (such as number of large customers) would be to mitigate the beta effect. For transport, there are few very large customers</td>
<td>Fuel consumption elasticities: Overall: short-run -0.15, long-run -0.30. VKT elasticities: Overall: short-run (&lt;1 year) -0.12, long-run (5+ years) -0.24.</td>
</tr>
<tr>
<td>Firm’s real options - in particular the option to adopt new products (“growth” options)</td>
<td>Existence of growth options should increase the firms sensitivity to real GNP shocks, as the value of these growth options should be more sensitive to real GNP shocks than the firm’s value exclusive to them. Black and Scholes show that the sensitivity of an option value to an underlying variable (and hence that of a firm possessing one) will vary with the term to maturity of the option and with how close is it to “the money”.</td>
<td>The early stage of a new road/ferry/rail connection therefore may be more sensitive to a shock, however over time as the new connection matures that sensitivity decreases.</td>
</tr>
<tr>
<td>Operating leverage</td>
<td>A higher operating leverage in general (higher fixed operating costs to total operating costs) should magnify asset betas, because cashflows will be more sensitive to own demand and hence to real GNP shocks.</td>
<td>NZTA operates on cashflow and has little to no leverage. It could be considered that as a Crown Entity, NZTA has a percentage of debt equivalent to the Crown’s total debt.</td>
</tr>
<tr>
<td>Market weight</td>
<td>Increasing an industry’s weight in the market proxy against which its beta is defined will draw its beta towards 1.</td>
<td>Note electricity distributors and possible comparators generally have limited weights in market indexes. (Lally 2005)</td>
</tr>
<tr>
<td>Industry, i.e. the nature of the product or service.</td>
<td>Firms producing products with low income elasticity of demand (e.g. necessities) should have lower sensitivity to real GNP shocks than firms producing products with high income elasticity of demand (luxuries), because demand for their product will be less sensitive to real GNP shocks.</td>
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</tbody>
</table>
Based on the identified characteristics and risk assessment, a sample set of comparators for NZTA can be identified. These comparators being regulated networks such as electricity, gas and water entities, or mature infrastructure assets such as a developed toll road. Key characteristics of these comparators are:

- Nature of the product/service – network infrastructure providing necessities e.g., electricity, gas and water.
- Nature of the customer – like other regulated infrastructure entities there are effectively no external customers.
- Degree of monopoly power – NZTA has a large degree of monopoly power.

### Comparator Beta Estimates

Within New Zealand outside of regulated network entities (Lines, Electricity generation, gas) there are no comparator firms. The few logistics firms in New Zealand do not have the same characteristics as NZTA and therefore are not suitable comparators. Asset betas for New Zealand network entities have an asset beta estimate range of 0.2 to 0.4. This asset beta range is similar for Australia, Europe, UK and USA.

A further source of comparator beta are global toll road comparator firms.

**Table 3: Global toll road asset beta estimates**

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>Asset Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinci SA</td>
<td>France</td>
<td>0.18</td>
</tr>
<tr>
<td>Albertis Infraestructuras SA</td>
<td>Spain</td>
<td>0.13</td>
</tr>
<tr>
<td>Atlantia</td>
<td>Italy</td>
<td>0.33</td>
</tr>
<tr>
<td>Brisa Auto-Estradas-Priv SHR</td>
<td>Portugal</td>
<td>0.32</td>
</tr>
<tr>
<td>Macquarie Infrastructure Group</td>
<td>Australia</td>
<td>0.58</td>
</tr>
<tr>
<td>Transurban Group</td>
<td>Australia</td>
<td>0.28</td>
</tr>
<tr>
<td>Hills Motor Group</td>
<td>Australia</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>0.29</strong></td>
</tr>
</tbody>
</table>

### NZTA Asset Beta estimate

Noting the characteristics of NZTA in particular as a regulated monopoly network with low exposure to GNP shocks, an asset beta estimate range of 0.2 – 0.4 is appropriate with a central estimate of 0.3. This central estimate is informed by beta from global toll road firms. This is in line with asset beta determinations by the Commerce Commission for Transpower and regulated gas and Electricity entities.


**Conclusion**

Based on the analysis outlined in this paper a discount rate of 6% (rounded) is recommended for the NZTA EEM, using the Social Opportunity Cost methodology where key assumptions are a New Zealand Equity Risk Premium of 7% and an NZTA asset beta of 0.4. Utilising the lowest estimates for equity risk premium (3.6%) and asset beta of 0.3 would generate a discount rate of 3.5% (rounded).

It should be noted that many of the issues surrounding the correct choice of the discount rate are still to be resolved and it should be expected that over time the choice of the discount rate will be revisited in light of new information.

*Caution required*

Benefit cost analysis is an important tool but not a substitute for judgement. The use of cost-benefit analyses is important in guiding the efficient allocation of public investment. However it is not a panacea, and considered judgement and thorough documentation of the assumptions is important.

Sensitivity analysis is recommended, not just on the discount rate but also on the benefits and costs of the proposed project. Discount rates are fundamentally a mechanism to connect the future with the present. To the extent that the future is uncertain and perceptions of future developments are reflected in today's expectations, then it is unreasonable to expect that there would ever be a single approach or a single discount rate that would meet with universal acceptance. Careful professional judgement, sensitivity analysis and transparent documentation available for public scrutiny are all required.

**Table 4: Discount Rate Formula and results**

\[
\text{WACC (real)} = \left[ \frac{(1 + \text{WACCn})}{(1 + i)} \right] - 1
\]

where:

\[
\text{WACCn} = \frac{[\text{RFR} \times (1 - \text{Tc}) + (\text{Ep} \times \beta_a)]}{(1 - \text{Te})}
\]

<table>
<thead>
<tr>
<th></th>
<th>Tc</th>
<th>Te</th>
<th>Ep</th>
<th>RFR</th>
<th>i</th>
<th>(\beta_a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc (corporate tax rate)</td>
<td>28%</td>
<td>28%</td>
<td>28%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Te (effective tax rate)</td>
<td>24%</td>
<td>24%</td>
<td>24%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ep (equity risk premium)</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RFR (risk free rate)</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i (inflation rate)</td>
<td>2.5%</td>
<td>2.5%</td>
<td>2.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>asset beta</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>WACCn</th>
<th>WACC real</th>
<th>Recommended NZTA Discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.42%</td>
<td>7.50%</td>
<td>6.58%</td>
</tr>
<tr>
<td></td>
<td>5.78%</td>
<td>4.88%</td>
<td>3.98%</td>
</tr>
<tr>
<td></td>
<td>6.00%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References


Dimson, E., Marsh, P. and Staunton, M., 2012 Credit Suisse Global Investment Returns Yearbook 2012, Credit Suisse


