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What are the theoretical discount rates of transport investments under the recent economic conditions?

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Abstract

The mechanism of discounting is to convert future costs and benefits to an equivalent amount in today's dollars commonly known as Present Values. The 7 percent central discount rate, recommended in both Australian and New South Wales economic appraisal guidelines, has been used for 40 years. However, there have been increasing calls for using a lower discount rate given low interest rates and investment returns in recent years. This paper examined economic returns from investment in debt and equity market, inflation rate, debt margin, risk premium, debt to equity ratio, income growth and consumption patterns in the last 5, 15, 30 and 40 years to estimate theoretical discount rates. We have tested all available models conventionally used for deriving discount rates from producer and consumer's perspectives. Our analysis estimated a central discount rate of 5.9%. However, a range of discount rates from 2% to 8.9% could be theoretically supported from available models and related investment return datasets and economic indicators used for informing the discount rate.

1. Introduction

The discount rate is one of most important parameters used in economic appraisal of transport projects. The 7 percent central discount rate, recommended in both Australian and NSW guidelines (Transport and Infrastructure Council 2018, Infrastructure Australia 2018 & 2021, NSW Treasury 2018, TfNSW 2019), has been used for 40 years. The discount rate used in Australia is high compared with rates used in other developed countries as shown in Table 1. In recent years, there are increasing calls for using a lower discount rate. For example, Grattan Institute (Terrill and Batrouney 2018) advocated using 3.5 percent discount rate for very low systematic risk projects and 5 percent for low systematic risk projects. The main reasons quoted for a lower discount rate are historically low interest rate and low economic returns from investments in debt and equity markets.

This paper examined models and related datasets to derive theoretical discount rates to inform discount rate debates. However, we do not take a position whether the current discount rates adopted in the infrastructure business cases and economic appraisals are high or low.

Table 1 International comparison of discount rates in project economic appraisal

Country	Recommended discount rate and evaluation period in economic appraisal	Appraisal period
England	3.5% for first 30 years then 3%.	Default 60 year operating life
Germany	3%	Component specific service lives and annuity factors
Netherlands	2.5% (plus 3% risk premium)	Varies, e.g. 100 years or infinite
Sweden	3.5%	Varies 40-60 years depending on type of investment
USA	Federal: 7% with sensitivity for 3%; States: vary 3-7%	Varies depending on project life cycle, typically 25 – 30 years
Australia	7 %, with sensitivity tests of 3%, 4% and 10%.	30 years
New Zealand*	4% with sensitivity tests of 3% and 6%. The rate was 10% during the 1990s and up until 2010 when it was reduced to 8%. It was reduced to 6% in July 2013 and 4% in August 2020.	For a 4% discount rate, the standard analysis period remains 40 years. An increase of the analysis period to 60 years is permitted to ensure that the whole-of-life costs and benefits of long-lived infrastructure activities are captured.

Source: Mackie and Worsley (2013, p.21), NSW Treasury (2017, p.15)

* Waka Kotahi NZ Transport Agency, Discount Rate and Analysis Period, A Technical Paper Prepared for the Investment Decision-Making Framework Review, November 2019; Waka Kotahi NZ Transport Agency, Monetised Benefits and Costs Manual, August 2021;

In Australia, Infrastructure Australia (2021, p. 23) requires the economic appraisal at 4%, 7% (for the central case) and 10%. Federal Department of Infrastructure, Transport, Regional Development and Communication (DITRDC) requires a parallel presentation of economic appraisal at discount rates of 4% and 7%[1] in that both rates appear to be central cases. NSW Treasury (2017) requires 7% central discount and 3% and 10% for sensitivity tests. Therefore most economic appraisals have been undertaken for 3%, 4%, 7% and 10% to meet both Federal and NSW requirements.

2. Framework

The theory of discounting is to convert future costs and benefits to a common time unit to compare costs and benefits that accrue at different times and express them as an equivalent amount in today's dollars commonly referred as Present Values (PV). We used four models, i.e. Return of Risk Free Market (RRFM), Capital Asset Pricing Model (CAPM), Weighted Average Cost of Capital (WACC) and Rate of Social Time Preference (RSTP), to infer the theoretical discount rates.

Inputs to these models are investment and economic datasets including Commonwealth 10-year bond rates that represent risk free rate of return, market rates of return on capital and/or debt investments, debt margin, risk premium, inflation rate and equity beta.

To derive appropriate discount rates, we need to predict the future values of these investment and economic indicators. However, no one can really predict the future thus it is reasonable to say that the debate on discount rate can never be settled.

[1] Presentation of 4% and 7% is a requirement of Project Proposal Report (PPR) as part of "Notes On Administration for Land Transport Infrastructure Projects 2019-2024".

The same to all forecasting techniques, we can only rely on historical data to build statistical models to project the future. This approach is consistent to economic theories that the broad economic activities follow cycles. In a longer period, the economic return for investment will “regress to mean” that support a stable discount rate.

We collected the investment and economic datasets for 40 years (from 1981 to 2020) to predict the theoretical discount rate for the following scenarios:

- Short period – The last 5 years using data from 2016 to 2020. When people called for a lower discount rate, they were likely to refer the investment performance for this period.
- Medium period – The last 15 years using data from 2006 to 2020.
- Typical evaluation period – The last 30 years using data from 1991 to 2020. Transport projects adopt an evaluation period of 30 years thus the discount rate derived from 30-year period may give most relevant indication.
- Long period – The last 40 years using data from 1981 to 2020. Most transport infrastructure lasts over 100 years. However, forecasting investment return beyond 40 years becomes much uncertain.

3. Discount rate models

3.1. Return of Risk Free Market (RRFM)

Consumers and producers would receive a return from investing in debt in risk free market. The rate of return is expressed in Equation (1):

$$Return\ of\ Risk\ Free\ Market\ (RRFM) = \left[\frac{1 + RFIR + DM}{1 + IR}\right] - 1 \qquad (1)$$

The RRFM is a function of Risk Free Interest Rate (RFIR), Debt Margin (DM) and Inflation Rate. We use the Commonwealth 10-year bond rate to represent the RFIR. Figure 1 shows that, in the last 5 years, the Rate of Return on Risk Free financial products was low.

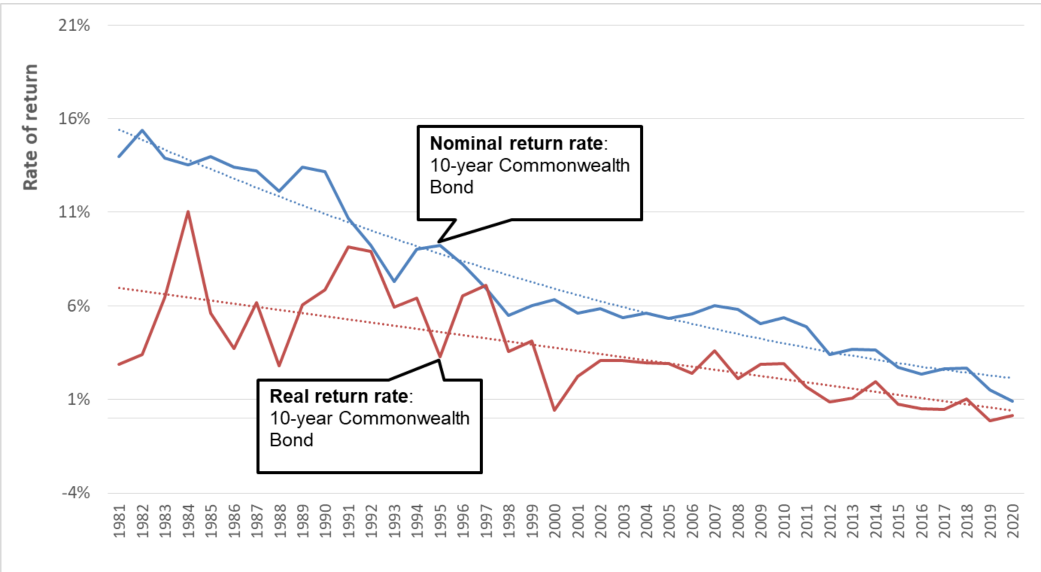

Figure 1: Risk free rate of return, 1981 - 2020

The debt margin is the difference between the cost of debt and the risk free rate. The debt margin represents the costs of debt raising and an additional return required by debt holders to compensate for risks a company will default on paying debt. This paper used a debt margin of 1.6% sourced from IPART's WACC model (IPART 2018). We used the Consumer Price Index (CPI) for all Australian capital cities to represent the inflation rate (IR).

Table 2 presented the estimated real RRFM pre-tax rate. The discount rate from the estimated RRFM is 2.0% for short-term, 2.4% for medium-term, 4.6% for the typical project evaluation period and 5.1% for long term.

Table 2 Return of Debt Investment in Risk Free Market (RRFM)

	Short-term 5 years	Medium-term 15 years	Typical project evaluation period	Long-term 40 years
Nominal Risk-Free Interest Rate (RFIR)	2.0%	2.8%	5.4%	7.5%
Debt Margin (DM)	1.6%	1.6%	1.6%	1.6%
Expected Inflation Rate (IR)	1.6%	2.0%	2.4%	3.8%
Real Return of Risk Free Market (RRFM) (pre-tax)	**2.0%**	**2.4%**	**4.6%**	**5.1%**

3.2. Capital Asset Pricing Model (CAPM)

Producers would receive a financial Return from Investing in Equity (RIE) that can be estimated from the Capital Asset Pricing Model (CAPM) that can be mathematically represented in Equation (2):

$$\begin{aligned} &Return\ from\ Investing\ in\ Equity \\ &\quad = RRIR + Risk\ Premium * \beta_E \\ &\quad = RRIR + (RMW - RFIR) * \beta_E \end{aligned} \tag{2}$$

The Return from Investing in equity is a function of the Return of Risk Free Market (RRFM) plus a risk premium. The Risk Premium, being defined as the difference between the Return from the Market as a Whole (RMW) and the Return of Risk Free Market (RRFM) estimated in Section 3.1. The risk premium is usually analysed from the difference between 25-year cumulative returns over 10-year government bond. The Equity Beta (β_E) is a measure of volatility or systemic risk of equity investment in a range from 0 to 1 where 1 indicating low systemic risk. Transport project investment has a relatively low systemic risk with an average Equity Beta of 0.87. Table 3 presents the estimated return from the CAPM model. The discount rate from the CAPM is 2.8% for short-term, 4.5% for medium-term, 7.8% for the typical project evaluation period and 8.9% for long term.

Table 3 Return of equity investment estimated from CAPM

	Short-term 5 years	Medium-term 15 years	Typical project evaluation period	Long-term 40 years
Nominal Risk-Free Interest Rate (RFIR)	2.0%	2.8%	5.4%	7.5%
Risk Premium	2.0%	3.0%	4.0%	4.5%
Equity Beta	0.87	0.87	0.87	0.87
Corporate Tax Rate	30.0%	30.0%	30.0%	30.0%
Nominal CAPM return (pre-tax)	4.5%	6.6%	10.4%	13.1%
Real CAPM return (pre-tax)	**2.8%**	**4.5%**	**7.8%**	**8.9%**

3.3. Weighted Average Cost of Capital (WACC)

Producers receive a return on investing a mix of debt and equity. Even if a transport project is wholly Government funded, a proportion of funding may be from debt of Federal and State Governments. Weighted Average Cost of Capital (WACC) provides a tool that the return from both debt and equity and associated risk can be considered in one model as shown in Equation (3):

$$WACC = RD * \frac{D}{D+E} + RE * \frac{E}{D+E} \tag{3}$$

The expected return on equity (RE) is higher than the return on debt (RD). The debt to equity ratio will impact on the required return on the total investment. In a private financing project, the debt to equity ratio can be calculated from the project financial structure. For public funded transport projects, IPART (2018) suggested a gearing ratio of 50% to 60%. The discount rate estimated from WACC is 2.3% for short-term, 3.2% for medium-term, 5.9% for the typical project evaluation period and 6.6% for long-term as shown in Table 4.

Table 4 Weighted Average Return of Capital (WACC)

	Short-term 5 years	Medium-term 15 years	Typical project evaluation period	Long-term 40 years
Expected return on debt (RRFM)	2.0%	2.4%	4.6%	5.1%
Expected return on equity (RE)	2.8%	4.5%	7.8%	8.9%
Proportion of debt D/(D+E)	60.0%	60.0%	60.0%	60.0%
Proportion of equity E/(D+E)	40.0%	40.0%	40.0%	40.0%
Real WACC (pre-tax)	**2.3%**	**3.2%**	**5.9%**	**6.6%**

3.4. Consumer rates

Consumers prefer to receive the same amount of goods and services sooner rather than later. Accordingly, the discount rate should be the marginal social rate of time preference, that is, the rate at which society is willing to postpone a marginal unit of current consumption in exchange for more future consumption. The one relevant rate is the interest earned by consumers on their savings, which has shrunk in recent years. Another relevant rate is the Social Time Preference Rate (STPR) that can be estimated from Equation (4):

$$STPR = TP + CG * \varepsilon \quad (4)$$

Table 5 indicates that the Social Time Preference Rate, being the pure time preference rate (TP) and the product of expected growth in consumption (CG) and the elasticity of marginal utility of consumption (ε), is relatively low between 2.0% and 3.4%.

Table 5 Consumer rates

	Short-term 5 years	**Medium-term 15 years**	**Typical project evaluation period**	**Long-term 40 years**
Rate of interest earned by consumers on their savings	2.0%	2.4%	4.6%	5.1%
Pure time preference rate (TP)	1.0%	1.0%	1.0%	1.0%
Expected growth in per capita consumption (CG)	0.7%	1.0%	1.7%	1.7%
Elasticity of the marginal utility of consumption (ε)	1.425	1.425	1.425	1.425
Social Time Preference Rate (STPR)	**2.0%**	**2.4%**	**3.4%**	**3.4%**

Source: Rate of interest earned by consumers on their savings is assumed at the same rate of the expected return on debt, which is based on nominal risk free interest rate, expected inflation, debt margin and tax rate. The pure time preference rate is based on an international literature review on time preference considering myopia rate and life expectancy. The expected growth in per capita consumption is based on historical income per capita in NSW. Elasticity of marginal utility of consumption was based on seven Australian and international studies that provide this value.

4. Concluding observations

We have estimated three discount rates from producers' perspective (i.e. RRFM, CAPM and WACC) and two discount rates from consumers' perspective (i.e. interest earned from savings and STPR) for short, medium, typical evaluation and long-terms. When people discussed the discount rate they were likely to refer one of those 20 rates that we presented in Tables 2 to 5.

Both consumer and producer rates can be relevant to be used as transport project discount rate. The expected return from transport investment should reflect the opportunity cost of funding, which is the expected return from the next best investment alternative. All three producer rates (RRFM, CAPM and WACC) have merits, however the WACC may be most often used. In four time periods analysed, the typical project evaluation, being 30 years for transport projects, is most relevant. The analysis indicates that a range of discount rates from 2% to 8.9% can be theoretically supported with mostly likely rate of 5.9% based on economic and investment data from the last 30 years, as shown in Table 6.

Table 6 Range of discount rates from the analysis

	Low range	Central estimate	High range
Discount rate	**2.0%**	**5.9%**	**8.9%**

A lower discount rate can make more projects economically viable. The prioritisation and ranking of projects for funding could change in favour of projects with a larger proportion of benefits occurring further into the future. It is also important to note that a number of factors other than a discount rate will also affect the economic viability of an initiative, including the appraisal period, the ability to capture and quantify benefits, especially in the future where there is increased uncertainty/risk and the robustness of capital and recurrent operating expenditure estimates. However, there exist a range of theories and viewpoints amongst economic appraisal professionals, peak bodies and academics relating to discount rates. There is no absolute 'right answer' to the question of which discount rate should be applied for economic appraisal of public sector investment.

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