The Cost Decision:
A New Discount Approach for Net Cost Projects

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Abstract

This discussion paper proposes a new decision rule for economic investment theory, the Cost Decision, and describes a new discount approach for Net Cost Projects and the Net Present Cost Formula. The paper illustrates the problems faced internationally, at all levels of government, of assessing Net Cost Projects from a finance perspective. The paper discusses the Cost Decision in the controversial context of public-private partnerships and compares the four main alternative approaches to the Cost Decision currently used in practice. The paper is also relevant when analysing Net Cost Projects undertaken by private sector entities and individuals.

JEL Classification: G30

Key Words: Corporate Finance; Investment; Economic Investment; Finance Investment; Discount Rate; Net Present Cost Formula; Cost Decision; Net Cost Projects; Social Projects; Net Present Cost; Net Present Value; Public-Private Partnerships; and Public Finance.

1. Introduction

All levels of government have difficulty financially assessing mutually exclusive Net Cost Projects[1], also commonly referred to as social projects—over the life of Net Cost Projects; a government incurs expenditure where there will be no return of, or on, that money. This is the reverse of typical investors who invest with the expectation of financial gain from their investments. Although the financial assessment of mutually exclusive Net Cost Projects has been a problem for governments even before the establishment of the investment theory[2], in recent years, the problem has become more apparent with the formal introduction of public-private partnerships policy in many countries.

As with all forms of investment, Net Cost Projects have varying degrees of risk[3] and cash flow timings. Net Cost Projects need to be costed and compared with alternatives, even when a budget has been allocated, as any financial savings that may accrue can be reallocated. The requirement to follow this procedural principle is the governing underlying justification for public-private partnership policy and is termed 'value for money'[4].

Further, governments that do not know the actual Net Cost Project costings will have a distortion in their decision-making process. For example, say Project A is initially preferred to Project B, where the cost difference between the two projects is $X. However, should another valuation method indicate the cost difference between the two is larger at $Z, Project B may then become the preferred project.

When financially assessing mutually exclusive Net Cost Projects, the approach commonly adopted by most governments is to determine how existing investment theory applies to the project. The outcome of this research has led to questions about the application of investment theory. This paper proposes that it is critical to understand the difference between an economic investment and a financial investment. Figure 1 provides a summary of the proposed relationship between an economic investment, a financial investment, and a Net Cost Project.

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[1] Examples of Net Cost Projects are the construction of new public hospitals, schools, prisons, urban roads, and parks. In all cases governments are paying for the construction and operations of these facilities but obtain no return of, or on, the cash invested.

[2] Also commonly referred to as corporate finance or finance theory.

[3] *Risk* is the uncertainty of future cash flows.

[4] Value for money is commonly defined by governments as delivering infrastructure projects at the lowest risk-adjusted cost, for a given standard of service.

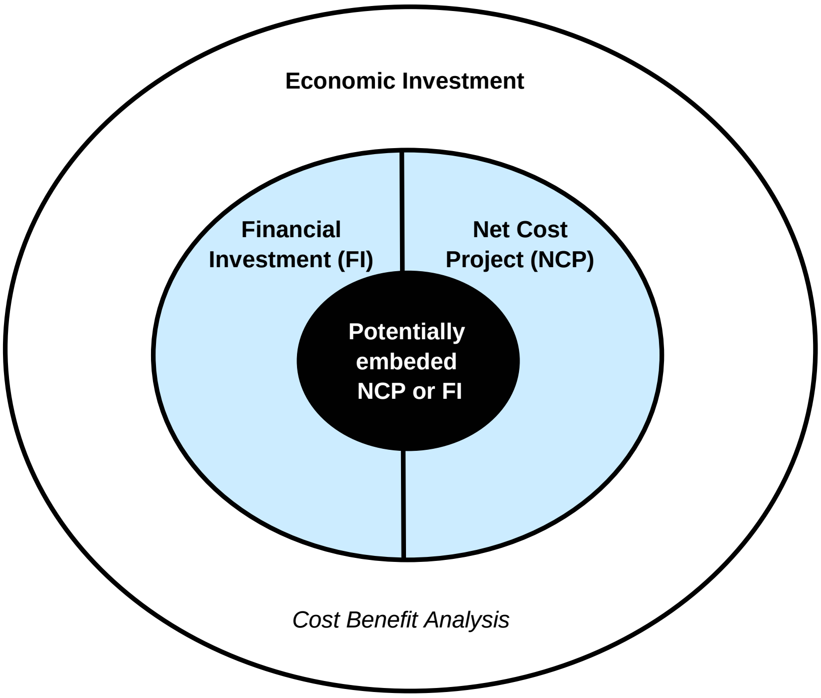


Figure 1 Relationship between an economic investment, a financial investment, and a Net Cost Project.

The prime purpose of this paper is to introduce a new decision rule for economic investment theory—the 'Cost Decision'. The Cost Decision determines how to financially rank mutually exclusive Net Cost Projects. It is proposed that the Cost Decision should be considered after the economic investment decision, but prior to the finance decision.

This discussion paper establishes the existence of the Cost Decision by discussing it in the controversial context of private-public partnership policy. The Cost Decision simply involves choosing the lowest risk-adjusted net present cost alternative — a concept commonly accepted by governments, academics, and practitioners. The reason for specifically proposing a new decision rule is to consider a new formula, the 'Net Present Cost Formula', to be used in place of the Net Present Value formula.

Three proofs are discussed. The first, and main proof, considers the definition of an investment, the difference between an economic investment and a financial investment, and the investor's utility function. The other two proofs substantiate the new approach using finance investment theory, although technically, these two proofs are not required; the reason for their inclusion is to assist some readers with the paradigm shift.

The paper assumes that the net benefit externalities, between the Net Cost Project alternatives, are either the same or are immaterial to the decision process. Further, any consideration of Net Cost Projects is from a quantitative perspective and not from a qualitative perspective. Justifiably, many projects have been undertaken for qualitative reasons even though the alternative project may be financially preferred, for example, where there is considerable technical risk in accepting the alternative project. Accordingly, this paper assumes that only quantitative considerations are important and any qualitative considerations are ignored.

Although this paper's prime focus is on discussing a Cost Decision embedded within an economic investment, it also discusses a Cost Decision embedded within a financial investment where, at the project investment level, there is a return of, and on, the cash investment. The paper concludes by defining areas for further consideration and research.

2. Defining a Net Cost Project

Net Cost Projects are commonly understood to be projects where a government must, over the life of the project, pay out money where there will be no return of, or on, that money. For the purposes of this paper, the definition a Net Cost Project is where the sum of a series of expected net cash outflows, with no allowance being made for risk or time value, is less than or equal to zero. It is generally understood that government infrastructure projects, or provision of services by government, are Net Cost Projects.

The two types of mutually exclusive Net Cost Project decisions commonly encountered by governments are:

1. Choosing the best procurement technique to deliver the desired outcome, for example, when providing 100 computers to a school should a government lease or buy the computers?

2. Different whole-of-life costing features that deliver the desired output specifications for a Net Cost Project, for example, when constructing a bridge should a government build it out of wood or concrete?

In government decisions, particularly public-private partnership projects, the two mutually exclusive decisions are normally combined. In public-private partnerships a government may have to choose between two different types of contractual relationships to deliver an infrastructure project outcome, where each uses different whole-of-life costing features. For example, either a long-term concession contract with a private sector consortium that finances the project and the Government pays a performance-linked payment to a consortium (a private finance solution) **or** the government decides to separately contract different components of the project and pay each contract separately (a public finance solution).

3. The Problems with Net Cost Projects

When considering mutually exclusive investment projects, the project with the highest Net Present Value (NPV) is the preferred project. Therefore, in mutually exclusive Net Cost Projects, it follows and is accepted that the lowest Net Present Cost project is preferred.

Current practice uses the Net Present Value formula to determine the Net Present Cost. The NPV is the equivalent value, expressed in today's dollars, of a series of future net expected cash flows. The NPV is calculated by discounting the cash flows, for time and risk, and then summing these discounted cash flows, and deducting the initial period cash flow investment into the project. The Net Present Value formula is:

$$(1)\ \text{Net Present Value} = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - C_0$$

The symbols have the same meaning as those on page 11, except Ct = net expected cash flow at time t.

However, there are three application problems evident when the Net Present Value formula is used to calculate the Net Present Cost of the Net Cost Projects:

	Problems[5]	Comments
1	Projects with the same cash flow timing but have different project rates	A higher project rate reduces the Net Present Cost of a project so that in two Net Cost Projects with identical net expected cash outflows the apparently preferred project will be the higher risk project. This is intuitively incorrect, as the project with the higher risk should cost more, not less, than the lower risk project. This is illustrated in Table 1.
2	Projects with the same project rate but different cash flow timing	If the net expected cash outflows of two Net Cost Projects sum to be the same, but the cash flow timings are different, the Net Present Costs will be different where the same project rate is used. This is a problem when the project rates do not equal the risk free rate[6], as there could be some residual impact of problem 1 in the Net Present Costs. This is illustrated in Table 1. This problem also captures the case where, instead of the net expected cash outflows summing to be the same, the sum of the net expected cash outflows for each project are different. However, when discounted at the risk free rate, the Net Present Costs of each project are the same. A project rate not equal to the risk free rate is then used to discount the net expected cash outflows. This case is not illustrated.
3	Projects with different cash flow timing and different project rates	This is a combination of problems 1 and 2, where the project rates and the timing of the net expected cash outflows are different for each Net Cost Project. However, the sum of the net expected cash outflow for each project is the same. This is illustrated in Table 1 and is the most difficult problem and the most common in practice.

[5] Note these problems only occur if the projects are mutually exclusive.

[6] This paper assumes the time value of money is the risk free rate. The r*isk free rate (rf)* is the return on capital that investors demand on risk free investments. The accepted proxy for the risk free rate is the interest rate on government securities that are considered to have no risk of default.

To illustrate the impact of these problems from an empirical sense, three simple examples have been devised. Each problem requires a choice of one of the two mutually exclusive Net Cost Projects. To ensure the problems and differences in the alternative solutions are highlighted numerically, a project discount rate and the cash outflows for each Net Cost Project are assumed, where no cash flow has any revenue component. The examples purposely ignore inflation and therefore apply equally to either a real or nominal analysis.

In practice, this simple comparison is unrealistic as making choices between different Net Cost Projects is normally very complex. In particular, the determination of the risk factor in each project is particularly difficult. This is discussed towards the end of this discussion paper. Table 1 below illustrates the three problems.

Table 1
The three problems

Project	Project Rate	Risk Free Rate	Sum of Cash Flows	Time Value Cost*	Net Present Cost**	Time and Cash Flows					
						0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
Problem 1 - projects with different risk											
A	8%	6%	-$10,000	-$9,212	-$8,993	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
B	14%	6%	-$10,000	-$9,212	-$8,433	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
Problem 2 - projects with different cash flow timings											
C	14%	6%	-$10,000	-$9,212	-$8,433	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
D	14%	6%	-$10,000	-$8,425	-$6,866	0	-2,000	-2,000	-2,000	-2,000	-2,000
Problem 3 - projects with different cash flow timings and risks											
E	8%	6%	-$10,000	-$9,212	-$8,993	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
F	14%	6%	-$10,000	-$8,425	-$6,866	0	-2,000	-2,000	-2,000	-2,000	-2,000

Notes * Use 6% (risk free rate) as the time value rate in the net present value formula
** Use the project rate in the net present value formula

Project A is assumed to have a risk premium of 2% over the risk free rate, while project B is assumed to have a risk premium of 8% over the risk free rate. These results, using the Net Present Value formula, indicate project B should be accepted rather than project A, as project B has the lowest risk adjusted cost. Intuitively, project A should be accepted as it is considerably less risky than project B.

Project C is assumed to have half the cash flow occurring in time zero, with the remainder of the cash flow spread evenly over future years. Project D is assumed to have no cash flow occurring in time zero, with the whole cash flow spread evenly over future years. Both projects are assumed to have a risk premium of 8% over the risk free rate. These results, using the Net Present Value formula, indicate project D should be accepted rather than project C, as project D has the lowest risk adjusted cost. Intuitively, project C should be accepted, as project D is considered riskier due to its expected project cash outflows in future years, being twice the size of project C. Therefore, the impact of the risk premium on the expected cash outflows should be greater for Project D. The risk premium will have no impact on the expected cash outflow at time zero for Project C.

Project E is assumed to have half of the total cash flows expected in time zero, with the remainder of the cash flows being spread evenly over future years. Project F is assumed to have no cash flow occurring in time zero, with the whole cash flow spread evenly over future years. Project E is assumed to have a risk premium of 2% over the risk free rate, while project F is assumed to have a risk premium of 8% over the risk free rate. This problem combines and accentuates the differences identified in problems 1 and 2. These results, using the Net Present Value formula, indicate a government should accept project F as it has the lowest risk adjusted cost. Intuitively, project E should be accepted as project F is seen to be substantially riskier, due to the project cash outflows in future years for project F being twice the size of project E and the risk premium is considerably higher for project F than project E.

In all three problems, if the Net Present Value formula is used, then intuitively the wrong decision will be made for each problem. This disparity occurs because decisions are based on the Net Cost Projects that have the lowest Net Present Costs, rather than on the investment projects that provide the highest NPV.

4. Competing Alternatives to the Problems

The international trend towards implementing public-private partnership policy for government infrastructure projects is a controversial example of the problems associated with financially assessing Net Cost Projects. Appendix A provides two such examples.

There has been in-depth discussion by academics and professionals all around the world, about how Net Cost Projects should be assessed within public-private partnership policy. Ultimately, each government must choose a method based on existing knowledge.

This paper considers the four main alternative methods currently adopted by governments; each approach is different and produces different outcomes. However, all four approaches centre on adopting alternative ways to determine the project rate used in the Net Present Value formula, to calculate the Net Present Cost of the Net Cost Projects. The four main alternatives are:

	Alternatives	Commentary
I	Add a percentage to the government's risk free rate.	In the United Kingdom (UK), HM Treasury in HM Treasury (1997), the former Treasury Guideline publication, applied a real discount rate of 6%, being a social time preference rate (refer Annex G). For comparison, the risk free market rate for the UK is often taken as the rate of return on indexed gilts. In 1996 the average return for 10 year indexed gilts was around 3.7%. Accordingly, the difference between the two rates was near 2.5%.
II	Allocate the systematic risk in the project rate between the government and private sectors. Use the risk free rate, plus the systematic risk allocated to the private sector, as the project rate to assess the private finance solutions.	Victorian Treasury, Australia in Partnerships Victoria Guidance Material (July 2003) state alternatives II and III are used where it is considered there is material systematic risk transfer to the private sector. In this alternative, the project rate for infrastructure projects is normally firstly determined by looking at the project rate of private sector infrastructure projects in the marketplace. Then there is a mechanism to allocate systematic risk between the sectors, resulting in the project rate for private finance solutions being able to be greater than the risk free rate.
III	Use the risk free rate as the project rate to assess public finance solutions.	Victorian Treasury, Australia in Partnerships Victoria Guidance Material (July 2003) use the risk free rate as the project rate to assess public finance solutions when making comparisons with private finance solutions.
IV	Reduce the project rate over the term of the project.	In the UK, HM Treasury in HM Treasury (2003),the current Treasury Guideline publication, use a declining long-term discount rate starting at a real discount rate of 3.5% as the social time preference rate (refer Annex 6). The rate decline only occurs after many years (the first rate reduction is to 3% in years 31─75). In 2003, the average return for 10 year indexed gilts was around 1.8%. Accordingly, the difference between the two rates was still near 2.5%.

Although these four approaches have been clearly identified for public-private partnership policy, the same type of approach is usually used by governments for the financial assessment of other mutually exclusive Net Cost Projects.

To ensure the problems, and differences, in the alternative approaches to discount rate determination can be numerically shown, the assumptions for the alternative approaches have been specifically selected. A case in point are the assumptions in alternative IV, where the rate declines quickly each year rather than slowly after many years, which is the current approach adopted by HM Treasury. The consistent assumptions in each of the alternatives are detailed in the tables below.

The main focus of the examples detailed below is to apply the four alternatives approaches to the three problems outlined earlier, in the context of a general Net Cost Project analysis, rather than in a public-private partnership context. To undertake the later, a subset of the alternatives and associated problems alone, needs to be examined. The only other assumption required is that all adjustments have already been made to the net expected cash flows. The examination does not need to be undertaken as a separate exercise, as the results from this general analysis apply equally to the subset.

Table 2 below illustrates the results of the four alternative approaches when applied to problem 1.

Table 2

Results of the four alternative approaches when applied to problem 1

Project	Project Rate*	Risk Free Rate	Sum of Cash Flows	Time Value Cost**	Net Present Cost***	Time and Cash Flows 0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
Alternative I: Net Present Cost - using net present value formula - add a percentage to the risk free rate											
A	9%	6%	-$10,000	-$9,212	-$8,890	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
B	9%	6%	-$10,000	-$9,212	-$8,890	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
Alternative II: Net Present Cost - using net present value formula - risk free rate plus the systematic risk allocated to the private sector											
A	7%	6%	-$10,000	-$9,212	-$9,100	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
B	10%	6%	-$10,000	-$9,212	-$8,791	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
Alternative III: Net Present Cost - using net present value formula - risk free rate											
A	6%	6%	-$10,000	-$9,212	-$9,212	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
B	6%	6%	-$10,000	-$9,212	-$9,212	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
Alternative IV: Net Present Cost - using net present value formula - reduce the project rate over the term of the project											
Raw Cash Flows											
A		6%	-$10,000	-$9,212		-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
B		6%	-$10,000	-$9,212		-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
Discounted Cash Flows											
A	8%	6%			-$9,284	-5,000	-926	-873	-840	-823	-822
B	14%	6%			-$8,652	-5,000	-877	-783	-712	-659	-621

Notes * Alternative 1: Use 9% (risk free rate plus 3%) for projects A and B as the rate in the net present value formula

Alternative II: Assume equal allocation of systematic risk. Use 7% for project A and 10% for project B (ie, the mid point between the risk free rate 6% and original project rate of 8% for project A and 14% for project B) as the rate in the net present value formula

Alternative III: Use 6% (risk free rate) for projects A and B as the rate in the net present value formula

Alternative IV: Use the project rate for projects A and B for year zero and year 1, then a reduction of 1% in the project rate each year (eg, Project A, yr 0=8%, yr 1=8%, yr 2=7%, yr 3=6%, yr 4=5%, yr 5=4%)

** Use 6% (risk free rate) as the time value rate in the net present value formula

*** Use the project rate in the net present value formula. For Alternative IV using the certainity equivalent method

Alternatives I and III, in table 2, do not reach a decision on which Net Cost Project has the lowest risk adjusted Net Present Cost. As stated in the explanation of problem 1, project A was intuitively the preferred project as project B was considered riskier. Accordingly, alternatives I and III do not provide a decision on which project should be forthcoming.

Alternatives II and IV, in table 2, provide an answer, but intuitively the wrong decisions are made. While alternative II narrows the difference in lowest risk adjusted Net Present Cost, alternative IV increases the difference when compared to the original problem.

Table 3 below illustrates the results of the four alternative approaches when applied to problem 2.

Table 3
Results of the four alternative approaches when applied to problem 2

Project	Project Rate*	Risk Free Rate	Sum of Cash Flows	Time Value Cost**	Net Present Cost***	Time and Cash Flows					
						0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
Alternative I: Net Present Cost - using net present value formula - add a percentage to the risk free rate											
C	9%	6%	-$10,000	-$9,212	-$8,890	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
D	9%	6%	-$10,000	-$8,425	-$7,779	0	-2,000	-2,000	-2,000	-2,000	-2,000
Alternative II: Net Present Cost - using net present value formula - risk free rate plus the systematic risk allocated to the private sector											
C	10%	6%	-$10,000	-$9,212	-$8,791	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
D	10%	6%	-$10,000	-$8,425	-$7,582	0	-2,000	-2,000	-2,000	-2,000	-2,000
Alternative III: Net Present Cost - using net present value formula - risk free rate											
C	6%	6%	-$10,000	-$9,212	-$9,212	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
D	6%	6%	-$10,000	-$8,425	-$8,425	0	-2,000	-2,000	-2,000	-2,000	-2,000
Alternative IV: Net Present Cost - using net present value formula - reduce the project rate over the term of the project											
Raw Cash Flows											
C		6%	-$10,000	-$9,212		-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
D		6%	-$10,000	-$8,425		0	-2,000	-2,000	-2,000	-2,000	-2,000
Discounted Cash Flows											
C	14%	6%			-$8,652	-5,000	-877	-783	-712	-659	-621
D	14%	6%			-$7,304	0	-1,754	-1,566	-1,424	-1,317	-1,242

Notes * Alternative 1: Use 9% (risk free rate plus 3%) for projects C and D as the rate in the net present value formula
Alternative II: Assume equal allocation of systematic risk. Use 10% for project C and D (ie, the mid point between the risk free rate 6% and original project rate of 14% for projects C and D) as the rate in the net present value formula
Alternative III: Use 6% (risk free rate) for projects C and D as the rate in the net present value formula
Alternative IV: Use the project rate for projects C and D for year zero and year 1, then a reduction of 1% in the project rate each year (ie, yr 0=14%, yr 1=14%, yr 2=13%, yr 3=12%, yr 4=11%, yr 5=10%)
** Use 6% (risk free rate) as the time value rate in the net present value formula
*** Use the project rate in the net present value formula. For Alternative IV using the certainity equivalent method

All alternatives provide an answer, but intuitively, the wrong decisions are still made. Further, all the alternatives narrow the difference when compared with the original problem.

Table 4 illustrates the results of the four alternative approaches when they are applied to problem 3.

Table 4

Results of the four alternative approaches when applied to problem 3

Project	Project Rate*	Risk Free Rate	Sum of Cash Flows	Time Value Cost**	Net Present Cost***	Time and Cash Flows 0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
Alternative I: Net Present Cost - using net present value formula - add a percentage to the risk free rate											
E	9%	6%	-$10,000	-$9,212	-$8,890	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
F	9%	6%	-$10,000	-$8,425	-$7,779	0	-2,000	-2,000	-2,000	-2,000	-2,000
Alternative II: Net Present Cost - using net present value formula - risk free rate plus the systematic risk allocated to the private sector											
E	7%	6%	-$10,000	-$9,212	-$9,100	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
F	10%	6%	-$10,000	-$8,425	-$7,582	0	-2,000	-2,000	-2,000	-2,000	-2,000
Alternative III: Net Present Cost - using net present value formula - risk free rate											
E	6%	6%	-$10,000	-$9,212	-$9,212	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
F	6%	6%	-$10,000	-$8,425	-$8,425	0	-2,000	-2,000	-2,000	-2,000	-2,000
Alternative IV: Net Present Cost - using net present value formula - reduce the project rate over the term of the project											
Raw Cash Flows											
E		6%	-$10,000	-$9,212		-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
F		6%	-$10,000	-$8,425		0	-2,000	-2,000	-2,000	-2,000	-2,000
Discounted Cash Flows											
E	8%	6%			-$9,284	-5,000	-926	-873	-840	-823	-822
F	14%	6%			-$7,304	0	-1,754	-1,566	-1,424	-1,317	-1,242

Notes * Alternative 1: Use 9% (risk free rate plus 3%) for projects E and F as the rate in the net present value formula

Alternative II: Assume equal allocation of systematic risk. Use 7% for project E and 10% for project F (ie, the mid point between the risk free rate 6% and original project rate of 8% for project E and 14% for project F) as the rate in the net present value formula

Alternative III: Use 6% (risk free rate) for projects E and F as the rate in the net present value formula

Alternative IV: Use the project rate for projects E and F for year zero and year 1, then a reduction of 1% in the project rate each year (eg, Project E, yr 0=8%, yr 1=8%, yr 2=7%, yr 3=6%, yr 4=5%, yr 5=4%)

** Use 6% (risk free rate) as the time value rate in the net present value formula

*** Use the project rate in the net present value formula. For Alternative IV using the certainity equivalent method

Like problem 2, all alternatives provide an answer, but intuitively, the wrong decisions are made again. Further, all the alternatives narrow the difference when compared to the original problem.

As highlighted above, in most cases, when applying the four alternatives to the three simple problems, the cost difference between the mutually exclusive Net Cost Projects is reduced. However, these alternatives do not provide the correct intuitive answer about the preferred Net Cost Project from a risk adjusted least cost perspective.

5. A Solution to the Puzzle

As previously stated, governments have been using the Net Present Value rule to determine the lowest Net Present Cost of the Net Cost Project alternatives. However, if the net externality benefits could be turned into a cash equivalent with more accuracy, and the economic project rate could be more accurately assessed, there would be no need to move to a least cost decision approach, as the economic investment decision (using the Net Present Value rule) should accurately assess the Net Present Cost alternatives. However, there are difficulties in obtaining the quantitative accuracy required for this secondary decision.

This is not to say the process is not sufficient to undertake the economic investment decision, but it does make it difficult when looking at the secondary decision of choosing between mutually exclusive Net Cost Projects embedded within that economic investment decision. Accordingly, to date, governments turned to financial investment theory to solve the problem.

The new discount approach to Net Cost Projects proposed in this paper, is founded on the premise that the Net Present Value formula cannot be used to financially rank mutually exclusive Net Cost Projects embedded within an economic investment decision, where these projects have no cash return of, or on, the cash investment. By comparison, the four alternatives detailed in the previous section, all use the Net Present Value formula.

The rationale for moving away from Net Present Value formula is that the Cost Decision is a risk adjusted least cost decision and is not an investment decision (economic or financial). Rather, as previously explained it is embedded within an economic investment decision and is not an investment decision in its own right. Accordingly, as the Net Present Value rule only applies to investment decisions, it should not be used. Further, a least cost decision is not a financing decision and, therefore, a whole new approach is required.

The new approach uses the certainty equivalent method, rather than the risk adjusted discount rate method, to determine the net present equivalent of a series of expected future net cash outflows.

For an investment project, the certainty equivalent approach provides the same NPV as the risk adjusted discount rate approach. The certainty equivalent approach lowers each net expected cash flow[7] by the systematic risk[8] (which is included in the project rate) to produce the value equivalent of safe cash flows[9]. The series of safe cash flows are then discounted at the risk free rate to produce the NPV. The risk

[7] *Expected cash flow* is the probability weighted average of all possible cash flows for a period of time.

[8] *Systematic risk* (also known as market or non-diversifiable risk) is that part of the total risk of a project that cannot be eliminated by investors through diversification, and is due to economy-wide factors.

[9] *Safe cash flow* is a cash flow which has been adjusted for risk and is therefore riskless (although this is from a systematic risk perspective and not a non-systematic risk perspective). A safe cash flow is also defined as a certainty equivalent cash flow.

adjusted discount rate approach discounts the expected cash flows by the project rate to produce the same NPV.

For a Net Cost Project, the approach is similar, but with one major difference — the net expected cash outflows for a Net Cost Project should be increased rather than decreased for risk, to make safe cash flows. Then, as in an investment project, the safe cash flows are discounted at the risk free rate to produce the Net Present Cost.

The formula for this new discounting approach to Net Cost Projects, the 'Net Present Cost Formula', is:

$$\text{(2) Net Present Cost} = C_0 + \sum_{t=1}^{n} \frac{C_t \text{ x } (1+r)^t}{[(1+rf)^t \text{ x } (1+rf)^t]}$$

where
C_0 = initial cash outlay
C_t = net expected cash outflow at time t
n = life of the project
rf = risk free rate
r = project rate
t = time period
Σ refers to the sum of the series

The following points are critical to the correct application of this formula:

- Although this formula is similar in presentation to a risk-adjusted discount rate, it is important to understand that this is a **certainty equivalent formula**.
- In its present form, this formula assumes that there is only one project rate. However, in the application of the formula, an assessment is required as to whether or not different project rates should be used for different time periods.
- The project rate should always be the risk free rate plus a premium for unknown or unexpected risk. The new terminology of 'unknown or unexpected risk' is introduced as that a Net Cost Project embedded in an economic investment is not a financial investment and therefore financial investment theory can not apply.
- In the practical application of this formula, some practitioners may choose to account for all risk in the determination of the net expected cash outflows. In making this choice, the risk free rate should be substituted for the project rate in the formula. The resulting collapse of the formula will leave the net expected cash outflows to be simply discounted at the risk free rate.

The critical element of the formula is $(1+r)^t/(1+rf)^t$ that is applied to each expected net cash outflow. As r will be greater than rf (unless r is assumed to be equal to rf) then the impact of the Net Present Cost Formula on the expected cash outflows is equivalent to a r less than rf in the Net Present Value formula. This is substantiated in the next section.

Table 5 illustrates the results of using the Net Present Cost Formula, instead of the Net Present Value formula, when it is applied to the three problems. It is assumed the same project rates as previously detailed; apply to the respective projects in each problem.

Table 5

Results using the Net Present Cost Formula when applied to the three problems

Project	Project Rate*	Risk Free Rate	Sum of Cash Flows	Time Value Cost*	Net Present Cost**	Time and Cash Flows					
						0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
Problem 1 - projects with different risk											
Raw Cash Flows											
A		6%	-$10,000	-$9,212		-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
B		6%	-$10,000	-$9,212		-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
Risk Adjusted Cash Flows											
A	8%	6%			-$9,447	-5,000	-1,019	-1,038	-1,058	-1,078	-1,098
B	14%	6%			-$10,223	-5,000	-1,075	-1,157	-1,244	-1,338	-1,439
Problem 2 - projects with different cash flow timings											
Raw Cash Flows											
C		6%	-$10,000	-$9,212		-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
D		6%	-$10,000	-$8,425		0	-2,000	-2,000	-2,000	-2,000	-2,000
Risk Adjusted Cash Flows											
C	14%	6%			-$10,223	-5,000	-1,075	-1,157	-1,244	-1,338	-1,439
D	14%	6%			-$10,446	0	-2,151	-2,313	-2,488	-2,676	-2,878
Problem 3 - projects with different cash flow timings and risks											
Raw Cash Flows											
E		6%	-$10,000	-$9,212		-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
F		6%	-$10,000	-$8,425		0	-2,000	-2,000	-2,000	-2,000	-2,000
Risk Adjusted Cash Flows											
E	8%	6%			-$9,447	-5,000	-1,019	-1,038	-1,058	-1,078	-1,098
F	14%	6%			-$10,446	0	-2,151	-2,313	-2,488	-2,676	-2,878

Notes * Use 6% (risk free rate) as the time value rate in the net present value formula

** Use the original project rate for each project as the rate in the net present cost formula

In an empirical sense, the Net Present Cost Formula provides the intuitively correct decision for all three problems in contrast to the four alternatives approaches. Table 6 summarises Tables 1 to 5 for comparative purposes.

Table 6
Summary of Tables 1 to 5

Compares Different Discounting Techniques to Address Problems 1 to 3 for a Net Cost Project		Problem 1 Projects with different risk		Problem 2 Projects with different cash flow timings		Problem 3 Projects with different cash flow timings and risk	
Method	Description	A	B	C	D	E	F
Normal	Using Net Present Value Formula - Use project rate.	-$8,993	-$8,433	-$8,433	-$6,866	-$8,993	-$6,866
		A preferred by	$560	C preferred by	$1,567	E preferred by	$2,127
Alternative I	Using Net Present Value Formula - Add a percentage to the risk free rate (assume 3% above risk free rate) and use as project rate	-$8,890	-$8,890	-$8,890	-$7,779	-$8,890	-$7,779
		Equal to	$0	C preferred by	$1,110	E preferred by	$1,110
Alternative II	Using Net Present Value Formula - The risk free rate plus the systematic risk allocated to the private sector and use as project rate	-$9,100	-$8,791	-$8,791	-$7,582	-$9,100	-$7,582
		A preferred by	$309	C preferred by	$1,209	E preferred by	$1,519
Alternative III	Using Net Present Value Formula - Use risk free rate as project rate	-$9,212	-$9,212	-$9,212	-$8,425	-$9,212	-$8,425
		Equal to	$0	C preferred by	$788	E preferred by	$788
Alternative IV	Using Net Present Value Formula - Project rate reduces over time (assume 1% reduction on the project rate from year two onwards)	-$9,284	-$8,652	-$8,652	-$7,304	-$9,284	-$7,304
		A preferred by	$632	C preferred by	$1,348	E preferred by	$1,980
New Approach	Using Net Present Cost formula rather than Net Present Value formula - Use project rate	-$9,447	-$10,223	-$10,223	-$10,446	-$9,447	-$10,446
		B preferred by	$776	D preferred by	$223	F preferred by	$999

6. Substantiating the New Discount Approach

It is appreciated that this paper will inevitably be viewed as controversial. Therefore, three separate approaches have been selected to provide the proof necessary to substantiate the New Discount Approach:

- The first approach is based on the founding principles of economic and financial investment theories. This approach is considered to be the only viable proof in respect of an economic investment, where there is no cash return of, or on, the cash investment.
- The second approach is presented to provide a clearer understanding of the New Discount Approach and specifically offers as proof, a utility function discussion, and assumes the project risk for Net Cost Projects can be priced using investment theory. This approach is the basis for the initiation of this paper.
- The final approach is for the skeptic's — its proof assumes investment theory must apply to financial assess mutually exclusive Net Cost Projects embedded within an economic decision, where there is no cash return of, or on, the cash investment.

After presenting these proofs, the Cost Decision embedded within a financial investment is discussed. Although this paper's focus is on how to evaluate a Net Cost Project that is embedded within an economic investment from a government's perspective, it is important to establish the financial investment link in order to substantiate the proposal.

A. General Assumptions

Like all theories, assumptions have been made to highlight core issues. For the purpose of the three proofs it is assumed that:

- A Net Cost Project has no revenue. This assumption is necessary to simplify the proof, although there is always a potential revenue cash inflow, albeit that it may not be sufficient to exceed the cash outflows. Some may argue that most infrastructure projects always have a revenue item, and that there should be at least a terminal value for the land content of any Net Cost Project. This argument is dismissed as with any terminal value assumption, the Net Cost Project will continue as a going concern and any land content will be retained and never sold. Accordingly, it is assumed for the purposes of the proofs, that the terminal value can be ignored, as it is the same value for the mutually exclusive Net Cost Projects.

- The least risk adjusted cost decision for mutually exclusive Net Cost Projects is independent of, and can be completely separated from; the finance decision—how a government chooses to fund the Net Cost Project cash outflows is irrelevant. This assumption is similar to the proposition established by Modgliani and Miller (1958). For governments with a strong financial standing, this assumption is valid. However, other governments may be limited in their financial options, which could lead to them choosing a different outcome even though it may be more expensive.

- There are no taxes. This assumption is the same as made in Modgliani and Miller (1958). For governments, this assumption is valid as governments are a collector of taxes and not a payer of taxes.

- The net benefit externalities between the Net Cost Projects alternatives are the same or immaterial in the decision-making process.

- Only quantitative considerations are important and any qualitative considerations are ignored.

B. Proof —Using the Founding Principles of Economic and Investment Theory

Many finance investment graduates may see economists as fortune tellers who are available to assist them with their investment decisions. Economists are quick to inform investment graduates that investment theory was born from economic theory, and although investment theory is considered to be a field in its own right, it will always have an important nexus with economic theory. Accordingly, in this paper, both theories are discussed.

B1. Economic Investment Theory

Both economic and investment theory use the Net Present Value rule to choose between possible investment decisions. Most universities will teach finance students that governments undertake a 'public benefit test' (also known as cost-benefit test) to evaluate whether they should undertake a particular project. The general rules for financially assessing an economic investment are to:

- Use the Net Present Value rule, that is, only accepts projects that have a positive NPV — an NPV greater than zero.
- Determine the appropriate discount rate to be used in the Net Present Value formula. This rate does not need to be determined using financial investment theory, but could be determined by applying economic theory, for example, using the 'social time preference rate'. An example is referred to in HM Treasury (2003).
- All externalities of the project should be captured, as far as possible, as a cash equivalent. Examples of relevant externalities affecting a road project are the reduction in road accidents, improvement in travel time and the environmental impact of noise and pollution. In economic terms, a new road could lower the costs of the providing health services and improve the economic activity of a large community, thereby providing net benefit externalities.

In reality, most people understand that governments cannot make decisions solely based on the highest NPV, because a minimum standard of service is required by the community across a wide selection of services. When providing a wide selection of projects for a community, governments assume projects are based on sound economic community investment decisions (whether from an economic, social, or environmental perspective) and thus any project undertaken by a government must have a positive NPV after factoring in the respective externalities. For the purposes of this paper, a community investment decision is an economic investment decision.

B2. Defining an Investment

Investment theory was established by notable economists such as Irving Fisher[10] and John Burr Williams[11]. Given that most readers understand the principles of finance investment theory, only a number of important aspects will be repeated in this paper.

What is the link between an investment in investment theory (herein termed 'financial investment') and economic theory (herein termed an 'economic investment')? Not only is this a difficult question to find an answer to in traditional texts, so is finding a simple definition of the word 'investment'. Some computer websites provided a guide, but the best definition of the word 'investment' was provided by Downes and Goodman (1991), a financial dictionary:

> 'Investment — is the use of capital to create more money, either through income producing vehicles or through more risk-oriented ventures designed to result in capital gain. Investment can refer to a financial investment (where an investor puts money into a vehicle) or to an investment of effort and time on the part of an individual who wants to reap profits from the success of his labour. Investment connotes the idea that safety of principal is important. Speculation, on the other hand, is far riskier.'

This definition highlights that a financial investment is one that provides cash return of, and on, the cash investment, whereas an economic investment provides an economic return of, and on, the investment. The economic return need not be just cash but includes the value of all externalities.

Williams (1938) in the preface to his work *The Theory of Investment Value* defines a financial investment as follows:

> 'Investment Value, defined as the present worth of future dividends, or of future coupons and principal, is of practical importance to every investor because it is the *critical* value above which he cannot go in buying or holding, without added risk. If a man buys a security *below* its investment value he need never lose, even if its price should fall at once, because he can still hold it for income and get a return above his cost price; but if he buys it above its investment value, his only hope of avoiding a loss is to sell to someone else who must in turn take the loss in the form of insufficient income.'

[10] Irving Fisher wrote many works in this area but his most cited work is 'The Theory of Interest'.
[11] The most notable works of John Burr Willams was 'The Theory of Investment Value' was originally published in 1938 by Harvard University Press. The author understands this is generally considered the first publication that considered investment theory as a discipline in its own right.

Williams, in his pioneering works on finance investment theory, also highlights that an investor must obtain a return of, and on, his initial cash investment.

The definition of financial investment for the purposes of this paper is that the sum of a series of expected net cash flows must be greater than zero (with no allowance for risk or time value). If the sum of the expected net cash flows equalled zero, then obviously there would be no return on the cash investment.

It is proposed that, from a government's perspective, an economic investment may or may not be a financial investment. However, a financial investment is always an economic investment from a government's point of view.

A government may undertake a project which is an economic investment, but not a financial investment—in fact it could be that the project only involves cash outflows. That is, if the project is a public hospital, although an economic investment, by definition in this paper, it is a Net Cost Project. Further, a government may not undertake a financial investment, even though it could obtain a return of, and on, the cash investment because it may not be an economically viable investment for the government, for example, timber milling of world heritage forests.

A financial investment in its purist form (buying shares or bonds) may be considered independent of economic investment theory, as any externalities are immaterial or non-existent. However, with more investors seeking 'socially responsible investments', this independence is diminishing.

A more complex project could be a financial investment from an investor's perspective and an economic investment from a government's perspective. However, a project may be a financial investment from an investor's perspective, but not an economic investment from a government's perspective, due to its negative externalities. An extreme example of this is when a project has substantially adverse social or environmental impacts, with no expected impact on the investor's return of, and on, the cash investment.

Key to any investment analysis understands from whose perspective an investment is being considered. In a commercial project there will always be different perspectives for the debt and equity holders. Likewise, one person's financial investment may be another person's Net Cost Project. Expanding this concept to public-private partnership policy, from the private sector's perspective entering into a private finance solution with a government is a financial investment. However, from the government's perspective it may be a Net Cost Project embedded within an economic decision.

B3. What is the Link between an Economic Investment and a Financial Investment?

The link between an economic investment and a financial investment is that both need a return of, and on, the principal. Both use the Net Present Value rule to assess whether or not a particular project should be undertaken.

Investment theory dictates that, due to qualitative considerations or capital rationing issues, projects with the highest NPV may not always be selected. Nevertheless, a positive NPV is desired. Likewise, economic projects with the highest NPV are not always implemented immediately, sometimes simply because a government cannot afford them.

B4. Examining the Link between Economic Investments and Net Cost Projects

Net Cost Projects have a different link to economic investments compared to financial investments. From the investor's perspective, Net Cost Projects are not undertaken as they do not provide a cash return on, or of, the cash investment. However, governments across the world undertake Net Cost Projects because they are necessary in a community sense, despite their substantial costs. If all of a project's externalities are able to be captured, valued in a monetary sense, and included in the expected cash flows, from an economic perspective, these Net Cost Projects would only be undertaken when they are considered to be an economic investment.

B5. Examining the Difference between an Economic Investment Decision and a Net Cost Project Decision

There are many mutually exclusive decisions that governments must make when considering infrastructure projects that are Net Cost Projects. These include:

1. What infrastructure projects must be undertaken as a priority and which projects can be delayed?

2. What are the desired outcomes for the government of a priority infrastructure project?

3. What delivery method and associated whole-of-life cost provides the best value for money and delivers the desired outcomes?

The first two decisions are economic investment decisions, as previously defined. The third decision is not an economic investment decision, as it assumes that any externality differences between the mutually exclusive Net Cost Projects are either the same or the difference is immaterial to the decision. This assumption is reasonable, as in most cases, the significant externalities are captured in the first two decisions with significantly fewer externality issues introduced in the third decision.

In essence, the economic investment decision is always the first decision that a government must make. Once the decision is made, a choice between mutually exclusive Net Cost Projects must be made, where the method of delivery and associated whole-of-life costs should be determined. There will always still be a requirement for some qualitative assessment before making this decision, for example, the financial viability of any counter-parties. As this paper focuses on how mutually exclusive Net Cost Projects are assessed financially, it is assumed that any existing qualitative issues are either the same, or the differences are immaterial to the decision.

This leaves the need for a purely quantitative analysis to determine the preferred Net Cost Project a government will use to implement the economic investment decision. This is the secondary decision, the 'Cost Decision'.

B6. Why a government chooses the Net Cost project with the Lowest Risk Adjusted Cost

The accepted practice is to choose the Net Cost Project that has the lowest risk adjusted cost. This choice is commonly accepted because in economic and investment theory, investors are considered to be risk-averse, which is normally proved by using an underlying utility function.

Another founding principle is how a risk-averse investor chooses between two mutually exclusive investment projects, whether economic or financial investments, that produce the same expected wealth but have different risks, as illustrated below in Figures 2 and 3.

Figure 2
Probability/Return Graph
Investment Project

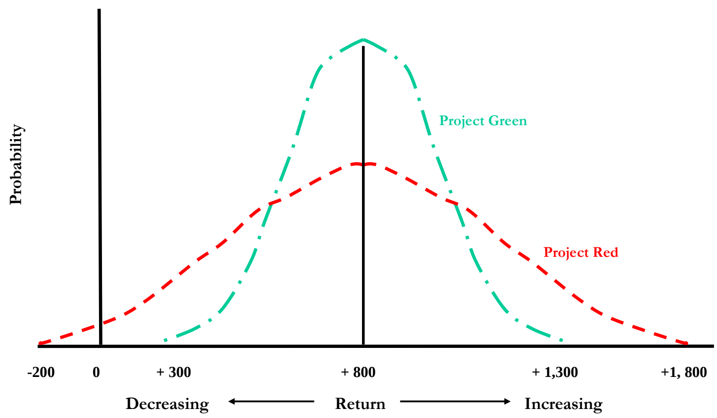
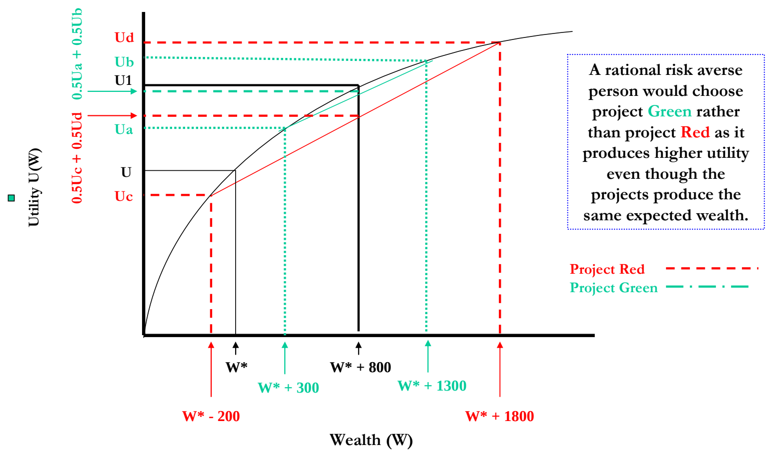


Figure 3
Utility Wealth Curve
Investment Project



Investment in project Red, offers the possibility of making either higher returns or lower returns, compared to investing in project Green. Although the increased spread of returns, above the expected return, tends to increase utility, this increase will be outweighed by the decrease in expected utility resulting from the greater spread of returns below the expected return. The risk-averse investor's expected utility would be greater with investment in project Green. Therefore, a risk-averse investor prefers investments that have a higher expected return for a given risk level and a lower level of risk for a given expected return.

As previously stated, in respect of the Cost Decision, choosing between two mutually exclusive Net Cost Projects is secondary to an economic investment decision, and therefore, the investor's utility function is still relevant. In making a choice, a government should still be considered risk-averse.

The preference of a risk-averse government in deciding between two mutually exclusive Net Cost Projects that produce the same expected cost, but where project Red is financially riskier than project Green, is illustrated in Figures 4 and 5.

Figure 4
Probability/Return Graph
Net Cost Project

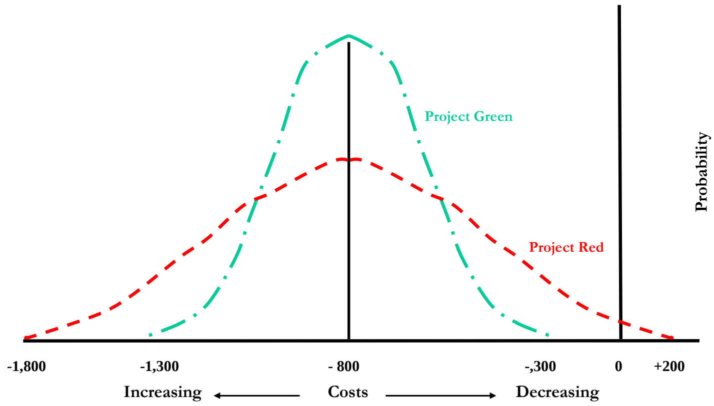
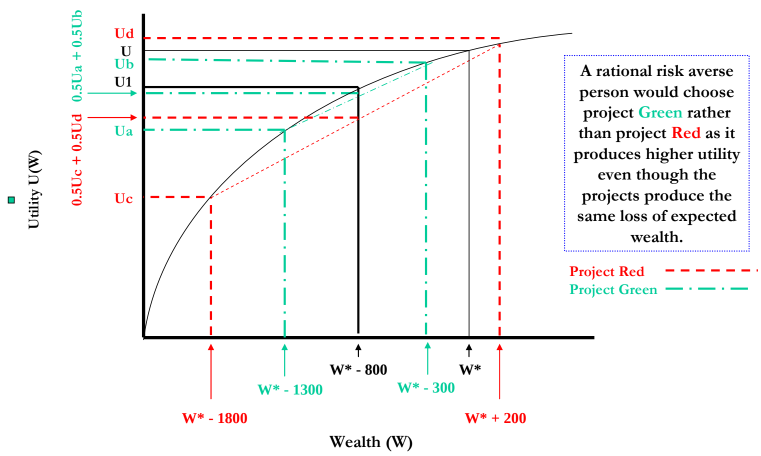


Figure 5
Utility Wealth Curve
Net Cost Project



Undertaking project Red offers the possibility of making a return, or it will cost the most, when compared with undertaking project Green. Although the increased ability to make a return above the expected cost tends to increase the utility, this increase is outweighed by the decrease in the utility resulting from the greater cost below the existing government financial resources.

As both Net Cost Projects offer the same expected cost, the risk-averse government's choice implies that the increased dispersion makes project Red riskier. Therefore, the risk-averse governments expected utility would be greater if the government undertook project Green.

In summary, a risk-averse government, choosing between two mutually exclusive Net Cost Projects, will choose the one that has the lowest expected cost (for a given risk level) or a lower risk (for a given expected cost). A risk-averse government has a positive attitude towards minimising cost and a negative attitude towards risk. This is reflected in most government's public-private partnership policies that define value for money as the lowest risk adjusted cost for a given level of service.

B7. The Impact of Risk when Choosing between Mutually Exclusive Net Cost Projects

A choice between two mutually exclusive Net Cost Projects should only be considered once an economic investment decision has been made. It is important to reiterate that this outcome results from the assumption that the externalities between different Net Cost Projects are either the same or any difference is considered immaterial.

So, the choice between two mutually exclusive Net Cost Projects is not an investment decision, because the Cost Decision is embedded within an economic investment decision. And given it is not an investment decision in its own right and there is no ability to rely on the economic investment decision methodology to make this secondary choice, the Net Present Value rule and investment theory cannot be used. How then should risk be treated?

From Figures 4 and 5 it is evident that when choosing between two Net Cost Projects, risk is something that could increase the expected cost of the Net Cost Project. Accordingly, risk to a risk-averse government is something that could increase the expected cost of the Net Cost Project. This differs from an investment decision, where risk to a risk-averse investor is considered, using the Net Present Value rule, as something that could reduce the expected return from the project. Nevertheless, in both circumstances, the main concern is that risk could reduce utility.

B8. What are the Different Types of Risk for a Net Cost Project

Similar to investment projects, two types of risk are foreseen for a Net Cost Project:

- Known or expected risk

  This is similar to non-systematic risk[12] in financial investment theory.

- Unknown or unexpected risk

  This is similar to systematic risk in financial investment theory.

Although both risks are similar to financial investment theory, each risk should be treated as being distinctly different and independent of financial investment theory because a Net Cost Project is not a financial investment. A practical example of the two risks is the impact of inflation on different Net Cost Projects:

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12 *Non-systematic risk* (also known as project specific or diversifiable risk) is that part of the total risk of a project that can be eliminated by investors through diversification.

- Economists normally provide a forecast about the expected inflation range, and a government's central bank will usually forecast a target range for inflation. Both forecasts are predictions of known or expected inflation. As with investment theory, cash flows should be increased to account for the known or expected impact of inflation.

- Sometimes events occur in a macro, or world, sense that causes inflation expectations to change dramatically. This sort of inflation is best defined as being unexpected or unknown inflation. In investment theory, this type of risk is normally only one component of the risk premium that is included in the risk adjusted discount rate. In investment theory and the Net Present Value rule, it is considered this type of risk will decrease the expected return from the investment and lower the investment's NPV. However for Net Cost Projects, the expected cost should be increased for this type of risk.

Therefore, any discounting methodology for choosing between mutually exclusive Net Cost Projects should increase expected cash outflows for known/expected and unknown/unexpected risk events. In the Net Present Cost Formula, the known/expected risk is allowed for in the net expected cash outflows, while unknown/unexpected risk is included in the formula $(1 + r)^t/(1 + rf)^t$, that is, increases the expected cash outflows.

C. Proof—Using Components of Investment Theory

This particular proof assumes an understanding of and acceptance of the prior proof that, in all cases, a risk-averse Government must account for risk by increasing, not decreasing, the expected cost of a Net Cost Project.

However, this proof makes the assumption that the capital asset pricing model (CAPM) is the best model for pricing the unknown/unexpected risk in Net Cost Projects embedded within economic investments. Although a potential method for cross-checking the pricing of unknown/unexpected risk, it should not be regarded as the best model in the case of economic investment projects. Potential methods for pricing the unknown/unexpected risks in Net Cost Projects embedded within economic investments are discussed later.

CAPM, in its simplest form, states that risk-averse investors should seek to invest where they can obtain an expected project return equal to the sum of the risk free rate, plus a premium for the systematic risk of the investment (the project rate). An investor should not be compensated for the non-systematic risk as the investor can diversify the risk. When undertaking a NPV analysis, the non-systematic risk must be included in expected cash flows.

The premium for systematic risk is measured by considering the covariance between the investment, or the best proxy for the investment, and the market portfolio ('the market') as a whole. The exact methodology will not be discussed here.

For a Net Cost Project, it is reasonable to assume, as costs increase over time, that there may be some positive covariance to the market as a whole. That is, as the market increases, costs also increase. Therefore, a premium for systematic risk could be equal to, or greater than, zero (that is, a positive premium) in the project rate for Net Cost Projects.

However, while a risk-averse investor needs to be compensated for the systematic risk to reduce the NPV of the investment project, a risk-averse government needs to be concerned with the systematic risk increasing the Net Present Cost of the Net Cost Project. The third proof shows why CAPM produces a negative beta[13] for a positive correlation between net cash outflows and the market as a whole.

So how should a risk-averse government calculate the Net Present Cost for a risk-adverse government? The new approach centres on using the certainty equivalent approach rather than the risk adjusted discount rate. The difference is that the net expected cash outflows of a Net Cost Project should be increased for systematic risk. This is achieved by multiplying the net expected cash outflows by one plus the project rate and then removing the time value component of the project rate, that is, $(1+r)^t/(1+rf)^t$.

As the net expected cash outflows have been adjusted for systematic risk, they are now safe cash flows in-line with the certainty equivalent approach. The safe cash flows are discounted at the risk free rate to obtain the Net Present Cost of the Net Cost Project. Accordingly, a new formula is produced for discounting Net Cost Projects, the 'Net Present Cost Formula'.

D. Proof—Using Financial Investment Theory Only

The final proof is for the skeptics. In this proof, it is assumed that a Net Cost Project is a financial investment decision and that the Net Present Value rule is used. As in the second proof, CAPM is assumed to be the best model to price the risk.

To differentiate between the two prior proofs, this proof assumes the Net Present value rule applies and that a beta can be determined for a Net Cost Project embedded within an economic investment. This proof is for those who do not agree with the validity of the main proof. This proof does not rely on, nor discusses, the underlying utility function, or the definition of investment.

[13] *Beta* is a measure of the systematic risk inherent in a project. Under the CAPM, it is used to calculate the premium for the project risk. The beta measures the volatility of a project relative to the overall market. The market has a beta of one, while investments with a higher systematic risk, compared to the

This proof shows that the same result can be obtained using the Net Present Value formula instead of the Net Present Cost Formula. This is achieved by establishing that a Net Cost Project will normally have either a negative or zero beta.

Financial students are normally taught that the existence of a negative beta is theoretically possible, but in practice it is non-existent. However, two published articles discuss negative betas. Both Schwab (1978) and Lewellen (September, 1977)[14] made the following observations when considering conceptual problems with risk-adjusted discount rates:

- Schwab (1978) stated that, 'Contrary to what is commonly assumed, risk-adjusted discount rates will not always exceed the riskless rate, but should be smaller than the riskless rate where risky cash outflows are evaluated.'

- Lewellen arrived at the same conclusion using the CAPM theory and established that risky cash outflows that are positively correlated to the market benchmark should produce a negative beta calculation.

This is because there is a negative covariance between the return on the risky cash outflows and the return on the market, as a return on a cost item must, by definition, be negative. So, although the cash outflows decrease as the market decreases showing a positive correlation, the return on both are negatively correlated producing a negative covariance and, in turn, a negative beta. The calculation of the resulting negative beta is illustrated in Table 7 below.

market have a beta greater than one and investments with a lower systematic risk compared to the market have a beta less than one. In this paper beta refers to the asset beta.

[14] Also refer to the related papers Celec and Pettway (September, 1979), and Lewellen (September, 1979).

Table 7

Beta Calculation - Cost to the Market

Data

Date	Mkt	Cost	Rc*	Rm	Date	Mkt	Cost	Rc*	Rm
Jan-99	156	-2.10			Jul-01	288	-3.07	-0.05	0.04
Feb-99	142	-1.85	0.12	-0.09	Aug-01	311	-3.14	-0.02	0.08
Mar-99	137	-1.78	0.04	-0.04	Sep-01	316	-3.05	0.03	0.02
Apr-99	150	-1.95	-0.10	0.10	Oct-01	327	-3.27	-0.07	0.03
May-99	151	-1.93	0.01	0.01	Nov-01	329	-3.31	-0.01	0.01
Jun-99	144	-1.79	0.07	-0.05	Dec-01	319	-3.30	0.00	-0.03
Jul-99	144	-1.79	0.00	0.00	Jan-02	342	-3.41	-0.03	0.07
Aug-99	151	-1.81	-0.01	0.05	Feb-02	354	-3.39	0.01	0.03
Sep-99	159	-1.93	-0.07	0.05	Mar-02	375	-3.52	-0.04	0.06
Oct-99	162	-1.89	0.02	0.02	Apr-02	403	-3.53	0.00	0.07
Nov-99	158	-1.83	0.03	-0.02	May-02	404	-3.54	0.00	0.00
Dec-99	162	-1.83	0.00	0.02	Jun-02	402	-3.50	0.01	0.00
Jan-00	183	-2.02	-0.10	0.13	Jul-02	434	-3.98	-0.14	0.08
Feb-00	173	-1.85	0.08	-0.06	Aug-02	441	-3.87	0.03	0.02
Mar-00	180	-1.83	0.01	0.04	Sep-02	462	-3.83	0.01	0.05
Apr-00	209	-2.09	-0.14	0.16	Oct-02	484	-4.13	-0.08	0.05
May-00	221	-2.17	-0.04	0.06	Nov-02	473	-4.71	-0.14	-0.02
Jun-00	218	-2.12	0.02	-0.01	Dec-02	478	-4.90	-0.04	0.01
Jul-00	243	-2.27	-0.07	0.12	Jan-03	513	-5.24	-0.07	0.07
Aug-00	256	-2.35	-0.04	0.05	Feb-03	510	-5.42	-0.03	-0.01
Sep-00	267	-2.53	-0.08	0.04	Mar-03	557	-5.80	-0.07	0.09
Oct-00	260	-2.52	0.00	-0.03	Apr-03	603	-6.77	-0.17	0.08
Nov-00	282	-2.65	-0.05	0.09	May-03	618	-6.89	-0.02	0.03
Dec-00	296	-2.76	-0.04	0.05	Jun-03	599	-6.40	0.07	-0.03
Jan-01	298	-2.98	-0.08	0.01	Jul-03	584	-6.17	0.04	-0.03
Feb-01	295	-2.95	0.01	-0.01	Aug-03	624	-6.25	-0.01	0.07
Mar-01	303	-3.00	-0.02	0.03	Sep-03	666	-6.46	-0.03	0.07
Apr-01	308	-3.09	-0.03	0.02	Oct-03	755	-7.71	-0.19	0.13
May-01	273	-3.00	0.03	-0.11	Nov-03	770	-7.51	0.03	0.02
Jun-01	277	-2.93	0.02	0.01	Dec-03	823	-7.83	-0.04	0.07
					Jan-04	853	-7.46	0.05	0.04

Output

Regression Statistics	
Multiple R	0.719
R Square	0.517
Adjusted R Square	0.508
Standard Error	0.043
Observations	60.000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.112	0.112	61.975	0.000
Residual	58	0.105	0.002		
Total	59	0.218			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.002	0.006	0.290	0.773	-0.011	0.015	-0.011	0.015
X Variable 1	-0.830	0.105	-7.872	0.000	-1.041	-0.619	-1.041	-0.619

Results

Alpha	0.00	
Beta	-0.83	If costs are positively correlated to the market then this produces a negative beta
R Squared	0.52	

Notes * Rc measures the return on the cost as (current cost less prior cost)/prior cost however to convert to a return it must by nature have a change in sign

Accordingly, if the investment theory applies to Net Cost Projects embedded within an economic investment, then the Net Present Value formula should calculate the same Net Present Cost as the Net Present Cost Formula. When applying CAPM pricing principles to Net Cost Projects, a negative or zero beta will normally be produced. This is similar to adding a risk premium for unexpected or unknown risk to the Net Present Cost Formula.

This final proof is also an important stepping stone to the next sub-section.

E. Link between the Cost Decision and Financial Investment Decision

This paper focuses on discussing how to evaluate, from a government's perspective, mutually exclusive Net Cost Projects that are embedded within an economic investment. As well as this focus, it is also important to discuss the link between the Cost Decision and the Financial Investment Decision, where a Net Cost Project choice is made within a financial investment decision.

If a Cost Decision has a tangible link to a financial investment, for example, lease versus buying an income producing equipment, then a proper application of the financial investment theory should result in choosing the same alternative as the Cost Decision. The reason for this is that the financial investment theory should be able to make the secondary Cost Decision by using the financial investment decision, unlike the economic investment theory that cannot make a secondary cost decision.

As financial theory is discussed in this section to simplify the analysis, it is assumed the Modigliani and Miller assumptions apply and CAPM, using an asset beta, is the appropriate method for pricing the investment risk.

Consider a financial investment project where there is a secondary choice between mutually exclusive Net Cost Projects, and where that choice is embedded within the financial investment project. For simplicity, it is assumed the financial investment has a series of single expected cash inflows and a single series of expected cash outflows and there is choice between a series of expected cash outflows using either a lease payment profile or a buy profile (eg, the two different cash outflow profiles used in problem 2). As it is a financial investment, there are net expected cash inflows from the investment, which is a return of, and on, the cash investment.

Table 8 below provides a numerical example of this decision. Project G and Project H have the same expected cash inflows but different expected cash outflows, where the expected cash outflows from Projects G and H are the same as lease and buy cash flow profiles respectively.

Table 8
Single Beta Approach

Project	Project Rate	Risk Free Rate	Sum of Cash Flows	Time Value Cost*	Net Present Value**	Time and Cash Flows					
						0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
						0	3,000	3,000	3,000	3,000	3,000
G						0	-2,000	-2,000	-2,000	-2,000	-2,000
	10.7%	6.0%	$5,000	$4,212	$3,728	0	1,000	1,000	1,000	1,000	1,000
						0	3,000	3,000	3,000	3,000	3,000
H						-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
	10.7%	6.0%	$5,000	$3,425	$2,457	-5,000	2,000	2,000	2,000	2,000	2,000
	Difference				$1,272						

Notes * Use 6% (risk free rate) as the time value rate in the net present value formula
** Use the project rate in the net present value formula

If the same project rate of 10.7% (rounded) is used for the net expected cash inflows for both investment decisions, then Project G is preferred to Project H, because its value is greater by $1,272.

Now reconsider this decision using an accepted alternative approach which has different discount rates for revenues and costs within the project[15]. The different cash flows within the projects have different betas with a separate beta for the cash inflows and another for the cash outflows (herein termed the multi-beta approach). Now assume (i) the cash inflows beta, is the same for both Project G and Project H, producing a discount rate of 9%, and (ii) to further simplify the examples, the beta for the cash outflows is zero, producing a discount rate of 6%, a risk free rate. This assumption is reasonable because the third proof established that cash outflows could have a zero or negative beta. Table 9 calculates the NPV of Project G and Project H using the multi-beta approach.

Table 9
Multi Beta Approach

Project	Project Rate*	Risk Free Rate	Sum of Cash Flows	Time Value Cost**	Net Present Value***	Time and Cash Flows					
						0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
	9%	6%	$15,000	$12,637	$11,669	0	3,000	3,000	3,000	3,000	3,000
G	6%	6%	-$10,000	-$8,425	-$8,425	0	-2,000	-2,000	-2,000	-2,000	-2,000
			$5,000	$4,212	$3,244	0	1,000	1,000	1,000	1,000	1,000
	9.0%	6.0%	$15,000	$12,637	$11,669	0	3,000	3,000	3,000	3,000	3,000
H	6.0%	6.0%	-$10,000	-$9,212	-$9,212	-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
			$5,000	$3,425	$2,457	-5,000	2,000	2,000	2,000	2,000	2,000
	Difference				$788						

Notes * Use 9% (risk free rate plus 3%) for revenue inflows and 6% (risk free rate, a zero beta) for cash outflows in the net present value formula
Can use net present value formula as it produces the same answer as net present cost formula when using the risk free rate as the project rate.
** Use 6% (risk free rate) as the time value rate in the net present value formula
*** The sum of the two Net Present Values produces the Net Present Value for the Projects

By using this multi-beta approach, Project G is still preferred; however the difference in value of Project G and Project H has narrowed to $788. Note that in comparing the mutually exclusive Net Cost Projects, the Net Present Cost Formula would achieve the same decision and the same difference in value.

To achieve the same results in Table 9 for both projects G and H using the single beta approach, the project rate for each investment would need to be 16.4% (rounded) and 10.7% (rounded) respectively as illustrated in Table 10 below.

[15]For example, Schwab (1978) and Lewellen (September 1977). There are many other references on this point.

Table 10 Single Beta Approach											
Project	Project Rate*	Risk Free Rate	Sum of Cash Flows	Time Value Cost**	Net Present Value***	Time and Cash Flows					
						0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
G						0	3,000	3,000	3,000	3,000	3,000
						0	-2,000	-2,000	-2,000	-2,000	-2,000
	16.4%	6.0%	$5,000	$4,212	$3,244	0	1,000	1,000	1,000	1,000	1,000
H						0	3,000	3,000	3,000	3,000	3,000
						-5,000	-1,000	-1,000	-1,000	-1,000	-1,000
	10.7%	6.0%	$5,000	$3,425	$2,457	-5,000	2,000	2,000	2,000	2,000	2,000
	Difference				$788						

Notes * Solve for the proejct rate so the net present value equals the muli-beta net present value for each project
** Use 6% (risk free rate) as the time value rate in the net present value formula
*** Use the project rate in the net present value formula

By simply comparing the results in Tables 8 to 10, it may be argued that a Cost Decision alone cannot be used to determine the preferred cost alternative, even where the expected inflow and its corresponding systematic risk is the same between both Project G and Project H because the results have changed.

However, on further examination of the financial investment theory, the results of Table 9 and 10 are correct and the results in Table 8 are flawed. This is because the financial investment theory — Lev (1974), and Mandelker and Rhee (1984) — recognises operating leverage increases the asset beta, that is, an increase in fixed operating costs acts like financial leverage to increase the asset beta for that particular investment. Accordingly, as the cash outflows in Project G are greater than the cash outflows, post year zero, in Project H, the cash outflows in Project G cause the investment to have a higher project rate than the cash outflows in Project H.

This establishes that the Cost Decision, using either the Net Present Cost Formula or the Net Present Value formula, can stand up in its own right. When using either of the two formulas, care must be taken to ensure that risk is treated correctly in calculating the Net Present Cost.

Determining what should be the appropriate change in the investment project rate, using the single beta approach for choices between mutually exclusive Net Cost Projects embedded within a financial investment decision will, in practice, be difficult. Accordingly, the Cost Decision should have relevance in a financial investment decision as it ensures that the Cost Decision alternatives are independently assessed. It is important to restate that to use the Cost Decision; the choice between the Net Cost Project outflow alternatives must have an immaterial impact on the cash inflows and the risk on these cash inflows in the financial investment.

F. Preference for Net Present Cost Formula

For economic investments, where there is no cash return on, or of, the cash invested, the use of the Net Present Cost Formula is preferred to the Net Present Value formula because:

- The choice between two mutually exclusive Net Cost Projects is not an investment decision and therefore, the Net Present Value formula should not be used.

- Due to the different decision rules for mutually exclusive Net Cost Projects being the lowest Net Present Cost, and investment projects being the highest NPV, the formulas should be separated and a new decision rule introduced, the 'Cost Decision'.

- The Net Present Cost Formula clearly indicates that risk should be added to the expected net cash outflows rather than being embedded, and potentially lost, in the determination of the project rate in the Net Present Value formula.

- Application of the Net Present Value rule for investment decisions primarily uses a risk adjusted discount rate approach rather than a certainty equivalent approach. This is despite the fact there are proven problems in using a risk adjusted discount rate approach. The certainty equivalent approach provides more information for a government to base long-term infrastructure decisions on. Also, the expected net cash outflow adjustment for risk in each time period will be displayed, and summed up, in spreadsheet calculations, compared with having an adjustment embedded in the project risk and, in turn, the Net Present Cost.

7. Issues for Further Consideration

As this paper is only a discussion paper that sets out to establish a new decision rule and a new formula for choosing between mutually exclusive Net Cost Projects, it is impractical to discuss all the associated issues in detail. There are a number of issues that need further discussion and research:

A. The Pricing of the Premium for Unknown or Unexpected Risk

The Net Present Cost Formula uses a project rate that is defined as the risk free rate plus a premium for unknown or unexpected risk when used to assess mutually exclusive Net Cost Projects embedded within an economic investment.

There are several potential methods for pricing the premium for unknown or unexpected risks in Net Cost Projects embedded within economic investments including:

- Arbitrage Pricing Theory

  This theory, unlike CAPM, does not rely on efficient portfolios; rather it depends on macroeconomic influences (factors) and events unique to a company (noise). The risk premium is determined by factors only. However, although there is no premium for noise, there must be an allowance for it in the expected cash flows. Although from an investor's perspective noise is removed by diversification, it still needs to be captured in the expected cash flows when determining a net present equivalent.

  The Arbitrage Pricing Theory may assist in pricing of the risk premium for Net Cost Projects. In particular, a practical determination of which factors are relevant for a Net Cost Project, and the assessed sensitivity of the Net Cost Project to these factors, may be helpful.

- Undertaking mean-variance studies of a government's inflation index.

  Normally a government publishes a benchmark index for inflation used by many parties to set price escalations in contractual agreements. There are many components in an economy that contribute to the end consumer price inflation index, and some governments produce their own price indexes on the components of the economy. Arguably, these are components of the end consumer price inflation index and therefore the mean variance relationship between the two different indices should be investigated. Accordingly, a definition of project risk for some Net Cost Projects may be devised from this investigation.

- Using systematic risk as a proxy for unknown/unexpected risk.

  Use of systematic risk was discussed in the second and third proof. It is important to add that the correlation between the net expected cash outflows and the market must be carefully examined and should not be approximated by merely considering the closest proxy project rate, especially one that is a financial investment from an investor's perspective.

If a government is unsure of how to determine the premium for unknown or unexpected risk, **or** if it is immaterial to the particular decision, then as previously suggested, an alternative is to simply adjust the cash outflows for all risks and discount the Net Cost Projects at the risk free rate. In respect of an embedded Cost Decision in a financial investment, the asset beta, or other accepted investment pricing methodology for the cash outflows, may be the preferred method.

B. Treatment of a Revenue Component in a Net Cost Project

Complex infrastructure projects, which may produce some external revenue for governments, require that careful consideration be given to risk issues for Net Cost Projects. It is preferable for these potential risk issues to be clear and transparent. When revenue streams need to be risk-adjusted, the first step, where possible, is to separate the project into a Net Cost Project decision and a financial investment decision.

C. Link between the Cost Decision and Lease versus Buy Literature

There is already a significant body of literature on how to assess a lease versus buy decision. In practice, it is generally accepted that a decision-maker in a lease versus buy analysis should use the borrowing rate as the project rate in the Net Present Value formula.

For a government making this decision, the Net Present Cost Formula produces the same result when the government accounts for unexpected/unknown risk in the expected cash outflows. In both cases, the government's borrowing rate is generally used — it is accepted as the proxy for the risk free rate.

However, from a non-government entity's perspective, the borrowing rate will obviously be higher than the risk free rate, as most non-government borrowing costs are normally more expensive. The lease versus buy decision can be split into two separate decisions: the Cost Decision and the Finance Decision. This split into two separate decisions would be preferable as a thorough evaluation of the risk associated with each separate decision is likely to eventuate.

D. Relevance to Non-Government Entities

Although this paper has been prepared from a government perspective, it is relevant to non-government entities, particularly when choosing between mutually exclusive Net Cost Projects that have net benefit externalities, for example, projects of an administrative nature, such as IT system projects, where the direct link to an increase in cash revenue is less tangible.

E. A Cost Decision Embedded within a Financial Investment

As the existence of a link between the Cost Decision/Net Present Cost Formula and the financial investment theory has been demonstrated, there is no reason it cannot be used when assessing the Cost Decision embedded within a financial investment. Arguably, application of financial theory may be preferred by some.

F. The In-Between

An area requiring further analysis is the decision applied to choosing between mutually exclusive projects that have a negative NPV, but are not a Net Cost Project as defined for the purposes of this paper. Obviously this decision would still be an economic investment decision, but the methodology for evaluation, as a general rule of thumb, would still be the Net Present Value rule.

8. Concluding Comments

This paper proposes a new decision rule, the Cost Decision, to assist with determining how to financially rank mutually exclusive Net Cost Projects. The Cost Decision should be considered after the economic investment decision, but prior to the finance decision.

The Cost Decision simply involves choosing the lowest risk-adjusted Net Present Cost alternative. This paper also proposes a new formula, the Net Present Cost Formula, to be used instead of the Net Present Value formula. The Net Present Cost Formula simply increases (rather than decreases) the net expected cash outflow for risk and then discounts the risk adjusted cash outflow by the risk free rate.

The Net Present Cost Formula is substantiated from both:

- an empirical perspective, as it provides an intuitively correct answer to the three practical problems detailed in this paper, in comparison to the current alternatives approaches adopted by governments
- a theoretical perspective, with various proofs discussed to substantiate the formula.

Although the focus is on a Cost Decision embedded within an economic investment decision, a link between the Cost Decision and financial investment theory is also established. This paper also has relevance for non-government entities, particularly when choosing between mutually exclusive Net Cost Projects that have net benefit externalities.

There is a need for further consideration and research of some important points, such as how to price risk for the Net Present Cost Formula, where the Cost Decision is embedded within an economic investment decision, and the link with lease versus buy finance literature.

This paper is a result of a desire to resolve the problems associated with determining the Net Present Cost of Net Cost Projects. It is hoped this paper will assist decision-makers by improving the quantitative analysis of mutually exclusive Net Cost Projects.

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Appendix A — References to the problems of financially assessing Net Cost Projects

There are multiple references to this problem world-wide.

The following two quotes nave been selected from private public partnership reviews conducted in Victoria, Australia, and the United Kingdom.

Fitzgerald, P. (2004):

> 'The Review of Partnerships Victoria Provided Infrastructure has been undertaken over the five months to January 2004 and involved a review of eight projects and the processes involved in their evaluation.
>
> The review has examined project economics and contract documentation and has been briefed on the details and progress of the projects, of which two are operational and one is presently being commissioned. Briefings and discussions have taken place with over 30 organisations and government agencies involved in the projects. Also, a public submission process was undertaken with the release of a Draft Report – emailed to over 150 people and downloaded from a website by a further 300.
>
> A total of 38 written submissions were received in response to the Draft Report. Of the 20 draft recommendations, all except four received broad support.
>
> The recommendations that enticed most disagreement relate to the proposed changes to the risk premium imbedded in the State's discount rate used in the evaluation processes. From the financial experts responding, the disagreement related to the practicality of estimating the value of transferred market risk, rather than its technical correctness.'

Institute for Public Policy Research (2001):

> 'In comparing the costs of the PFI project with its Public Sector Comparator, allowance has to be made for the fact that payments from the public purse for the capital element of a PFI scheme will be made at a later date than is the case under conventional procurement. A payment made later effectively costs less these future payments have to be discounted, using the Treasury's long established six per cent real pre-tax discount rate. A considerable debate has raged over whether this rate is appropriate for appraising PFI schemes. The lower the discount rate, the more attractive would be the conventional financing route (other things equal); a higher discount rate would favour the PFI. Some economists argue for a higher rate and some for a lower rate and some for using different discount rates for different projects (Grout, 1997). It should be noted that the private sector tends to use similar 'rough and ready' rules of thumb as the Treasury's six per cent rate.
>
> On balance, there appears to be merit in the argument for slightly lowering the benchmark discount rate now that the real costs of public borrowing have come down. For a typical PFI project, lowering the discount rate by one per cent would make the whole project about five per cent more expensive over its lifetime relative to the PSC. This would not stop PFI deals that offer significant value-for-money gains from proceedings though it would be sufficient to tilt the outcome for projects where the value-for-money case was very marginal. It is interesting to note that the NAO reported that London Underground examined the impact on its analysis of the Government's proposed PPP for the Tube of using a real discount rate of 3.5 per cent (NAO, 2000b).'

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