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An optimised multiple test framework for project selection in the public sector, with a nuclear waste disposal case-based example

C.B. Chapman *, S.C. Ward, J.H. Klein

School of Management, University of Southampton, Southampton SO17 1BJ, UK

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Abstract

Since 1967 the real (net of inflation) discount rate used to assess public sector projects in the UK has changed four times: from 8% to a peak of 10%, then to 5%, then to 6%, and then to the current position of 3.5% for years 1–30 declining in increments to 1% by year 300. This paper argues that the trend is in the right direction, but the associated decision process remains inappropriate, because the rationale for the changes has been flawed. Many other countries use discount rates of 6% or more in decision processes which are probably even more inappropriate. The fundamental problem stems from attempts by economists to embed too many conflicting considerations in a discount rate which is used in a single hurdle rate test. A multiple test approach is needed to address all the issues that the associated decision processes need to consider. This paper offers a way forward based on alternative economics perspectives, operational research perspectives, and established practice in a project risk management context. A case-based example concerned with the disposal of intermediate level nuclear waste in the UK illustrates how it works, and the implications of current UK practice, suggesting a very different view of a decision a decade ago which is a topical again. The proposed framework should be of interest to anyone interested in public sector projects, in the UK and elsewhere, and its generalisation has implications for private sector projects and private public partnerships (PPPs). Generic project risk management processes concerned with the whole of the project life cycle could embed a generalised form.

Keywords: Investment appraisal; Project selection; Public expenditure; Discounting; Generic project risk management processes; Nuclear waste disposal

1. Introduction

Investment appraisal to select projects in the public sector presents considerable difficulties. Potential investment projects are numerous, and they often involve large capital expenditures, benefits that are uncertain or difficult to quantify, and consequences which may be very long-lived. Decisions in any one year will be constrained by ongoing commitments, anticipated future levels of resources, and anticipated future demands on resources. Professor Sir Alan Budd, a distinguished former Chief Economic Advisor to HM Treasury, has argued that the public sector investment appraisal process is one of constrained optimisation [1]. In terms of constrained optimisation, the decision problem a government must address can be described as follows:

1. the primary objective of the government decision making process is maximising the expected net present value (NPV) of the portfolio of all current and planned public sector investments;
2. one secondary objective is seeking an optimal trade-off between this primary objective and associated downside risk;
3. further secondary objectives address optimal trade-offs between expected outcomes and associated risk in terms of all reasonable economic, political and social concerns not captured by a cost-benefit approach to NPV, and optimal trade-offs between these concerns;

* Corresponding author. Tel.: +44 23 8059 2525; fax: +44 23 8059 3844.
E-mail address: C.B.Chapman@soton.ac.uk (C.B. Chapman).

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4. secondary objectives include seeking an optimal size for the portfolio of public sector investments.

From an operational research (OR) perspective, the only way to make this operational is a goal programming [2] approach. The distinguishing feature of a goal programming approach is dealing with all secondary objectives via appropriate constraints, and managing trade-offs between objectives via shadow prices. More specifically:

1. the objective function in the mathematical programming framework is maximising NPV in expected value terms (the primary objective);
2. constraints limit values for all secondary objectives;
3. constraints express any required limitations on the available choices beyond those imposed by secondary objectives (for example, only one of two alternatives may be feasible);
4. a basis for trade-off analysis is provided by shadow prices, defining the change in the value of the primary objective function if any constraint is relaxed by one unit;
5. trade-off analysis involves adjusting the constants assumed for each secondary objective constraint on successive iterations until the shadow prices for all constraints reflect appropriate trade-offs.

The proposed role of this goal programming perspective is insight into simple decision rules. In principle it might be used directly. However, this paper argues that it should be used indirectly, as a 'maximum insight process', comparable to 'background theory', to develop a much simpler operational framework. This simpler operational framework should be based on a 'minimal process', for considering projects one at a time on a multiple test 'traffic light' basis, and a related 'intermediate process', to periodically review marginal projects on a portfolio basis and adjust the minimal process. This approach uses the concept of 'constructive simplicity', with origins in mainstream operational research [3], extensively developed in the context of project risk and uncertainty management [4]. Constructive simplicity implies starting operational modelling with minimal complexity, with the aim of facilitating transparency and understanding. Operational complexity is added only when it is useful. The concern is a flexible and general approach to optimising the decision process as well as the choices made using the decision process. This departs from most mainstream economic theory and practice associated with discounting for public sector investment selection. However, it is consistent with some very basic established economics principles, and operational research traditions which date back to the origins of OR. The latest advice from HM Treasury [5] can be interpreted as a first step in this direction.

Viewed within this framework, public sector investment appraisal to date has not progressed much beyond the first requirement of those on either list above. The focus of investment appraisal in the UK prior to the 2003 'Green Book' advice from HM Treasury [5] was the maximisation of NPV for individual projects using a single hurdle rate test. The 2003 Green Book considers multiple objectives via multiple tests explicitly for the first time, in line with our proposed framework. However, it does so one project at a time, without a basis for optimising the decision process. The limited international literature review undertaken by the authors suggests that the UK Treasury may be in the forefront internationally, in terms of both a realistically low discount rate and a multiple test decision process.

The basis of our proposed approach, and all other approaches, is NPV. For present purposes define the NPV of a project's costs and revenues as follows, using notation convenient for our example:

$$\mathrm{NPV} = -C_0 + \sum_{t=1\ldots n} S_t R_t^t + C_n R_t^n \qquad \text{(a)}$$

where n, life of project in years; t, $(1 \ldots n)$; C_0, initial capital expenditure; S_t, net cash flow in year, t, a saving in operating costs; R_t, discount factor for year t, $1/(1 + D_t/100)$; D_t, annual discount rate for year t (%); C_n, terminal value of the project.

In practice C_0, S_t, C_n and D_t may be uncertain, and D_t may be assumed to be constant D for all time periods. A project comprising a particular set of estimated cash flows is considered worth undertaking if $\mathrm{NPV} > 0$ for the 'correct' discount rate(s). For this calculation to have an economic meaning, use of the 'correct' discount rate(s) is essential. Moreover, the use of 'incorrect' discount rate(s) can induce important bias in investment decisions. Economists have recognised the importance of this bias for a long time. For example, Hawkins and Pearce [6] argue IRR (internal rate of return) rates (obtained by setting NPV equal to zero and solving for the discount rate) should never be used to choose between projects, because they have no economic meaning beyond their use for sensitivity analysis of a given single NPV calculation, a fundamental principle we endorse. Unfortunately, differences of opinion on the 'correct' discount rate have a long and confusing history which has lost sight of Budd's constrained optimisation view and the Hawkins and Pearce concern for a correct rate which does not induce bias.

While the authors are critical of HM Treasury recommendations on investment appraisal, they believe considerable sympathy for the predicament of HM Treasury and comparable bodies in other countries is warranted. The issues involved are exceedingly complex, and the relevant economics literature is very confusing. Disputes about 'correct' discount rates often involve incompatible basic framing assumptions, different world views, and conflicting political agendas, and these differences are usually implicit.

Private sector investment decision processes raise some similar issues, as do private public partnerships (PPPs). The differences are too significant to address here, but the common ground will be clear. A full synthesis of the relevant economics literature from the perspective of the