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A multiobjective model for the selection and timing of public enterprise projects

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Abstract

In theory, a public utility company improves the quality of community life through its projects and actions. However, project selection and prioritization by these companies are highly complex processes. To assist company planning managers in such processes, we propose a mixed integer programming model that selects, from a bank of projects, which are worthy of investment. The question of timing is also addressed. The model maximizes a weighted sum of normalized economic and financial net present values and a social impact index. It simultaneously satisfies a set of precedence relations among projects, the earliest and latest project start dates, exogenous budget limits, and endogenous project cash flow generation. We illustrate the model's effectiveness using an example constructed from a case study of a major Latin American water and sewage company.

Keywords: Project selection; Multicriteria decision-making; Public sector decision-making; Public investment decisions; Mixed integer programming

1. Introduction

Most public enterprises—including water, sanitation, transportation, and energy supply utilities—face a common problem: the current budget available for those investment projects that could potentially be undertaken during a planning horizon is insufficient to initiate all projects during the first year. Adding to the complexity of the decision process are technical limitations such as earliest and latest start dates and precedence relations between specific projects. Moreover, there may be substantial external political pressure, and internal bureaucratic support, for specific projects.

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Two additional considerations are as follows:

(1) Some projects—for example, those related to potable water supplies and electricity—may be at least partially self-financing in that consumers can be billed for them; while others—such as reforestation of hillsides and wetland restorations—must be funded from other sources. Thus, to some degree, the budget is endogenous.
(2) Unlike the private sector, in which maximizing net financial benefits or returns to shareholders is generally the sole criterion, the public sector must also consider social equity, economic, and political criteria.

The question thus arises as to what types of decision support systems (DSS) are currently available for public agency managers in such a complex environment. Theoretical and applied research in economics and operations research has provided substantial guidance in this area.[1] In economics, McGuire and Garn [1]—building on the project evaluation work of Eckstein [2], Marglin [3], and others—incorporated equity considerations into a project selection model by assuming that one can construct weights for each project's net benefits to each income group, where the weights depend on each group's income and employment levels. In contrast, Freeman [4] proposed that public administrators' past decisions be used to construct a societal welfare function that would allow project selection based on the marginal social value of each affected group's income. However, as Just et al. [5, p. 41] correctly pointed out, "little hope [apparently] exists for determining a *societal* welfare function on which general agreement can be reached."[2] Thus, as explained below, in the current paper we do not attempt to specify societal preferences but, rather, adopt a weighted set of widely accepted criteria as an objective function.

The operations research literature has naturally focused more on alternative models and solution algorithms. For example, Benjamin [6] proposed a goal-programming model for public-sector project selection in Trinidad and Tobago in which the goals are stipulated by the program manager. This model, which was applied to the energy sector, included economic, financial, social, and political factors but did not address project scheduling despite the author's recognition that scheduling is the second phase in public-sector investment problems. Much earlier, Lee and Sevebeck [7] used goal programming in their aggregative model for municipal economic planning. The model was applied to a small problem from the municipal government of Blacksburg, Virginia. More recently, Chan et al. [8] used a goal-seeking methodology within a capital budgeting framework in considering technology modernization by the US Army.

It is important to note that the approaches taken in these earlier studies all demand that managers specify a policy by explicitly setting goal levels for several criteria.[3]

Some researchers have used the analytical hierarchy process (AHP) to help managers identify their priorities. For example, Barbarosoglu and Phinas's [11] project selection tool for the Istanbul Water and Sewerage Administration used AHP and mixed integer programming (MIP) to include social, political and economic criteria. After first using AHP to quantify tangible and intangible attributes, and obtain an aggregate weight for each project, they used the resulting weights in the objective function of the project scheduling MIP model. Son and Min [12] also combined AHP and integer programming to solve a capital budgeting problem in the US electrical power industry, taking financial and regulatory (environmental) constraints into account.

Whereas these AHP-based approaches can include hard-to-quantify factors, the methodology's demanding pairwise comparisons tend to limit the size of the project bank. For instance, the above two experiments

[1]The economics literature is now, however, somewhat dated. Economic research on public investment criteria peaked during the era of large dam construction, which ended in the mid-1970s when the sites for such projects became scarce and environmental concerns brought a halt to most U.S. Army Corps of Engineers projects.

[2]The search for an acceptable social welfare function for use in public investment decisions has been long and largely unsuccessful. Such investigation has been characterized by three major approaches: (1) the subjective proposal of a specific analytical form; (2) the axiomatic construction of a social welfare function from widely accepted axioms; and (3) a moral justice-based approach that distinguishes between an individual's personal and moral preferences.

[3]Due to go-no-go decisions in some project selection problems, integer goal programming can be viewed as an alternative methodology [9] to that adopted in the current paper. Extensive reviews of techniques and applications of goal programming are provided by Schniederjans [9] and Tamiz et al. [10].