



A robust approach to the decision rules of NPV and IRR for simple projects



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ABSTRACT

We propose a robust approach to the decision rules of Net Present Value (NPV) and Internal Rate of Return (IRR) by building an analogy between robust optimization approach proposed in the literature and decision rules of NPV and IRR by considering uncertainty in cash flows. As proposed in the literature, we assume that the parameters, cash inflows and cash outflows in our case, belong to a symmetric and bounded interval set, and define a series of decision rules of NPV and IRR by considering robustness.

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1. Introduction

The general approach in determining the accept/reject/stay indifferent decision for a project via investment appraisal techniques such as NPV and IRR is to treat the cash flows as known with certainty. However, even small deviations from the predetermined values may easily invalidate the decision. Thus, redefined decision rules of investment appraisal techniques by considering the uncertainty in cash flows are indispensable for a reliable decision. For this aim, some approaches would be possible to consider the uncertainty in cash flows such as fuzzy approach and robust approach. In this paper, we propose to redefine the decision rules of NPV and IRR for simple projects in which there is only one sign change in the cash flows by using the idea of robust optimization approach proposed by Bertsimas and Sim [1].

Robust optimization was originally proposed by Soyster [2] who considered only the worst-case realizations of the coefficients of the constraints in which the coefficients are assumed to belong to predetermined convex sets. However, this consideration could yield an overconservative optimum solution. To alleviate the overconservatism of Soyster [2], Ben-Tal and Nemirovski [3] proposed to partition the coefficients of each constraint into an uncertainty set and a certainty set, while Bertsimas and Sim [1] proposed to tune the degree of overconservatism by defining so-called protection functions instead of merely considering the worst-case realizations. In robust optimization approach proposed by Bertsimas and Sim [1], the parameters belong to a symmetric and bounded interval set with unknown distribution. In this paper, we propose a robust approach to NPV and IRR decision rules in the sense that we redefine a series of decision rules in which we first consider the best-case and worst-case realizations of the cash flows given the set, a symmetric and bounded interval set as in Bertsimas and Sim [1], to which cash inflows and cash outflows belong. If the worst-case or best-case realization is not possible, then we propose to make a decision based on the predetermined parameters that measure the distance of worst-case and best-case realizations to “stay indifferent” position. If a decision still cannot be made at this stage, then as in Bertsimas and Sim [1], we propose to tune the degree of uncertainty in cash flows by defining so-called protection functions with the aim of adjusting the degree of conservatism.

The paper is organized as follows: In Section 2, a structured literature review has been proposed for uncertainty approaches to capital budgeting problems, and the contribution of the paper has been emphasized. In Section 3, robust NPV

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decision rules are defined, and illustrated by a three-period simple project example which gives more insights to the proposed decision rules. Thereafter, the condition for which the probability of a project to be rejected given that it is rejected in deterministic case will be more or less than the probability of the project to be accepted given that it is accepted in deterministic case is proved. In Section 4, robust IRR decision rules are defined, and illustrated by a three-period simple project example in which we use the same nominal values, and keep the basic assumptions in NPV example. For the computation of so-called protection functions defined in Bertsimas and Sim [1], parametric programming is proposed, since the right-hand sides of the constraints of the models used for the calculation of protection functions include unknown internal rate of return. In Section 5, the improvements of the traditional approaches and main drawbacks of the proposed approaches have been discussed. Finally, in Section 6, conclusions and potentials for future research are discussed.

2. Literature review

A substantial body of research has been devoted to uncertainty approaches to capital budgeting problems. In most papers, fuzzy optimization has been used to address the uncertainty in parameters such as cash inflows, cash outflows and discount rates. Table 1 provides some selected papers for fuzzy approaches to capital rationing and capital budgeting.

However, other uncertainty approaches including robust optimization approaches have been relatively scarce. Table 2 provides two papers for robust optimization approaches to capital budgeting problems.

Hanafizadeh and Latif [13] proposed a robust optimization approach to NPV similar to the approach proposed in this paper. However, they considered only the worst-case scenario and did not allow flexibility for tuning the degree of uncertainty. Their approach also lacks decision rules with respect to the risk position of the decision maker. Since the worst-case scenario can be too conservative at least for some situations, a robust approach with adjustable uncertainty level of the parameters is required for more real-life applicability.

3. A robust approach to the decision rules of NPV

In deterministic case, an NPV equation is defined by $NPV = \sum_{n=0}^N \frac{F_n}{(1+r)^n}$, where $F_n = b_n - c_n$ with b_n representing cash inflows and c_n representing cash outflows at period n . If $NPV > 0$, then the project is accepted, if $NPV < 0$, then the project is rejected. Finally, if $NPV = 0$, then the decision maker stays indifferent [14]. However, in this decision rule, cash inflows and cash outflows are assumed to be known with certainty in advance, and possible deviations from the predetermined values are not taken into account. The uncertainty level of cash inflows and cash outflows is especially subject to increase for the future time points. Since multiple cash flows are likely to change from their nominal values, the decision is also subject to be different from the decision made by considering the nominal values. Therefore, the decision is unlikely to be robust against the possible deviations with the traditional approach. With this concern, we redefine the NPV decision rules by borrowing the idea from robust optimization approach. As in robust optimization approach, we assume that the parameters,

Table 1
Literature review for selected fuzzy approaches to capital budgeting.

Paper	Uncertainty approach/uncertain parameters	Capital budgeting technique	Number of projects	Special solution approach
Kuchta [4]	Fuzzy parameters/cash flows, discount rate, project lives	Revenues per one dollar method, payback period method, net present value, net future value, method of utility of the net present value, internal rate of return, modified internal rate of return	Single project	–
Omitaomu and Badiru [5]	Fuzzy parameters/Cash flows, discount rates, project lives/	Present value	Single project	–
Huang [6]	Fuzzy chance-constrained/Cash inflows, cash outflows	0–1 integer programming as capital budgeting model	Multiple projects	Fuzzy simulation based genetic algorithm
Bas and Kahraman [7]	Fuzzy t-norm, t-conorm relations/ Cash outflows, NPV, budget	Pure capital rationing model	Multiple projects	–
Liao and Ho [8]	Fuzzy binomial/Probability of price to rise, probability of price to drop, call option values	Fuzzy NPV expanded with real options	Single project	–
Zhang et al. [9]	Fuzzy parameters/Net operating cash flows, benefits, costs, exchange rates	0–1 integer programming as multinational capital budgeting model	Multiple projects	Hybrid intelligent algorithm
Zhang et al. [10]	Fuzzy parameters/Cash inflows, cash outflows, NPV	0–1 integer programming as capital budgeting model	Multiple projects	Genetic algorithm
Tsao [11]	Fuzzy parameters/Cash inflows, cash outflows	NPV, equivalent annuity (EA)	Single project for NPV, multiple projects for EA	–

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