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Application of Modified Internal Rate of Return Method for Watershed Evaluation[1]

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Abstract

The use of modified IRR in developmental projects has been demonstrated by using data pertaining to four watersheds — two from Tamil Nadu and two from Maharashtra. The conventional internal rate of return (IRR) widely used in project evaluation, suffers from certain problems, most important one being the assumption of reinvestment at the rate of IRR, which has been often contested in project evaluation literature. The ranking of projects based on IRR and NPV may also come into conflict due to this assumption. Scale and time span differences across projects often make it difficult to compare. In India, the use of conventional IRR still prevails even though improvements have been suggested in literature long ago, perhaps for the reasons of ease in handling. Application of modified IRR method coupled with adjustment for scale and time span differences suggested in literature, has been demonstrated in this paper using data for watersheds. The study has shown that the rate of return from investment watershed is less lucrative when MIRR is used with necessary adjustments for scale and time span and the ranking based on IRR and NPV is consistent. The ranking of the projects has been found to change by using the adjusted MIRR methodology.

Introduction

Technical interventions have been the hall mark of developmental processes. They are capital-intensive with flow of benefits extended over a longer period of time. Since large amounts of public funds are spent in such interventions, there is a need for economic justification for the investment and for prioritisation of projects competing for limited resources. Thus, evaluation of various public investments is necessary.

The most common discounted measures, incorporating the time value for money, used for project evaluation are benefit-cost ratio (BCR), net present value (NPV) and internal rate of return (IRR). These techniques, known as capital budgeting techniques, though widely used and popular, have certain limitations. Further, their application for development projects like watershed poses additional problems due to nature and distribution of benefits and costs. In this paper, we have discussed the capital budgeting techniques used for project evaluation, problems with the use of IRR and modifications needed thereof.

Methodology and Data Base

Discounted capital budgeting techniques often used in project evaluation are: benefit cost ratio (BCR), net present value (NPV), and internal rate of return (IRR). These are briefly outlined below.

Benefit Cost Ratio (BCR)

BCR is the ratio of present value of benefits to present value of costs, and may be given by Equation (1):

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$$\text{BCR} = \sum \frac{B_t}{(1+r)^t} / \sum \frac{C_t}{(1+r)^t} \quad \ldots(1)$$

A project is viable and worth taking up when the BC ratio is more than 1. The main problem here is that BCR can be manipulated easily as its value is sensitive to the treatment and aggregation of costs and benefits. For example, taking benefit in the numerator net of a few cost items, which would have been otherwise accounted in the denominator, a different value for BCR may be obtained. Precisely for this reason, it becomes difficult to compare different projects unless a uniform method of aggregating benefits and costs is followed. Similarly, the ratio is also sensitive to the time span considered for project evaluation and comparing projects of different durations becomes untenable. Another problem is in its interpretation when applied to projects like watersheds where public funding and private benefits, non-correspondence between those who incur costs and those who benefit are the contentious issues.

Net Present Value (NPV)

It is the difference between PV of benefits and PV of costs and denotes the net worth of the project. It may be given by Equation (2):

$$\text{NPV} = -INV + \sum \frac{B_t}{(1+r)^n} \quad \ldots(2)$$

where, INV is the initial investment and in case a series of investments are made over the years, the present value of such costs $\left[\sum \frac{C_t}{(1+r)^n}\right]$ should be computed and used. The decision criterion as is selection of project with positive NPV and ranking the projects as per the magnitude of NPV in case of capital rationing.

Internal Rate of Return (IRR)

The earlier two measures are computed at a given rate of discount. Here the implied discount rate is computed such that PV of benefits equals the PV of costs. Thus, IRR is the 'r*' that can make NPV zero. That is,

$$\text{IRR} = r^* \text{ such that NPV} = \sum \frac{B_t}{(1+r^*)^n} - \sum \frac{C_t}{(1+r^*)^n} = 0 \quad \ldots(3)$$

The decision criterion is that projects with IRR greater than the cost of capital should be selected and under capital rationing, projects with higher IRR get priority over the others. IRR can be interpreted as the return per Rs 100 and is the most favoured measure since it is easy to understand and communicate. However, there are many problems with IRR as a criterion for project evaluation (Cary and Dunn, 1997; Anonymous, 2004). Some of them are:

- The IRR method can lead to erroneous rankings of mutually exclusive projects when compared to the net present value (NPV) method of capital budgeting,
- The IRR method assumes that the future cash flows will be reinvested and get the returns equal to IRR,
- IRR ignores differences in the size of the projects, the *scale problem*,
- IPR also ignores differences in the life of the projects, the *time span problem*, and
- Differences in the risk classes of the projects and capital rationing can also cause ranking differences if done based on IRR.

In literature, Modified Internal Rate of Return (MIRR) method of capital budgeting has been suggested to take care of the problems arising out of reinvestment assumption. When scale or time span differences exist, the MIRR method may still give rankings of mutually exclusive projects that are different than of NPV. Hence, IRR needs adjustments to take care of these problems. One may question the need for adjustments when evaluating, say watershed projects, which are not mutually exclusive and apparently are not subjected to capital rationing. Even if we buy these arguments, though difficult as the projects are competing for scarce public funds, the fact remains that an overestimated IRR due to reinvestment assumption gives false sense of profitability of the projects.

The problems can be sorted out by making adjustments to MIRR (Cary and Dunn, 1997) as detailed below.

MIRR can be calculated in two steps. First, the cash flows (CF_t) are converted to future value, FVCF, as at the end of the project period at a specified rate, k, usually the cost of capital.

$$FVCF = \sum_{t=1}^{n} CF_t \, (1+k)^{(n-t)} \quad \ldots(4)$$

Then, the rate of return the FVCF implies over the initial investment (INV), i.e. MIRR, is calculated using expression (5):

$$FVCF = INV(1 + MIRR)^n \quad \ldots(5)$$

$$MIRR = \left(\frac{FVCF}{INV}\right)^{\frac{1}{n}} - 1 \quad \ldots(6)$$

Since FVCF can be expressed in terms of present value (PVCF), we can write:

$$FVCF = PVCF(1 + k)^n \quad \ldots(7)$$

Hence, we can rewrite expression (6) for MIRR as Equation (8):

$$MIRR = \left(\frac{(INV + NPV)(1+k)^n}{INV}\right)^{\frac{1}{n}} - 1 \quad \ldots(8)$$

Adjustment of MIRR for scale differences involves assumption of a shadow investment with initial outlay equal to the difference in initial outlays of the two projects in consideration and zero NPV. If two projects A and B with initial outlays of INV_A and INV_B such that $INV_A < INV_B$, are to be compared, we will compute $MIRR_A$ using the expression (9):

$$MIRR_A = \left(\frac{(INV_B + NPV_A)(1+k)^n}{INV_B}\right)^{\frac{1}{n}} - 1 \quad \ldots(9)$$

Adjustment for time span differences differs from repeatable to non-repeatable projects. For repeatable projects, the time span can be brought to the same end point by either truncating the period of long span project or by extending the period of short-span project by using replacement chain.

For non-repeatable projects, adjustment similar to the one suggested above for scale differences can be followed and $MIRR_A$ for shorter span project can be computed using Equation (10):

$$MIRR_A = \left(\frac{(INV + NPV)(1+k)^N}{INV}\right)^{\frac{1}{N}} - 1 \quad \ldots(10)$$

where, N is the project period for longer-span project.

For adjusting both time span and scale adjustments, we can use expression (11):

$$MIRR_A = \left(\frac{(INV_B + NPV)(1+k)^N}{INV_B}\right)^{\frac{1}{N}} - 1 \quad \ldots(11)$$

To generalize, to compute MIRR for different projects use largest INV, N and uniform k, but NPV of the project for which MIRR is computed in the Eqation (11).

In India, BCR and IRR are the most common measures used to evaluate the projects. Hardly any attempt is made to use MIRR with or without adjusting for time span and scale differences. Simple MIRR can be computed in MS Excel using @MIRR(values,finance_rate,reinvest_rate) function. In this paper, the above methodology for modified IRR has been followed to re"evaluate a couple of watershed projects.

Results and Discussion

About Watershed Projects

We had selected 4 watershed projects in the present study to demonstrate MIRR methodology. The data for these watersheds were culled from three evaluation study reports (Deo, 1999; Prasad and Rao, 1999; and Kumar and Palanisami, 2004). Two of the selected watersheds are from Maharashtra and the other two are from Tamil Nadu. The watersheds were implemented during 1990s. The basic details of the watersheds are given in Table 1.

Table 1. Basic details of selected watersheds

Particulars	Watershed			
	Kattampatti	Kodangipalayam	Rajani	Shedashi-Wavoshi
Location	Coimbatore district, Tamil Nadu	Coimbatore district, Tamil Nadu	Yavatmal district, Maharashtra	Raigad district, Maharashtra
Period of implementation	1996-1999	1996-1999	1993-1999	1993-1999
Average rainfall (mm)	348	523	1116	2915
Reference year	2001-02	2001-02	1997-98	1997-98

Table 2. Costs and benefits in selected watersheds (in reference year prices)

(in lakh Rs)

Particulars	Watershed			
	Kattampatti	Kodangipalayam	Rajani	Shedashi-Wavoshi
Life of asset considered (n) in years	15*	15*	25	25
Expenditure (INV)	19.39	19.63	27.06	111.56
Net incremental benefits (per year)	7.32	7.01	40.94 from 6th year	6th to 14th year: 77.59 15th year onwards: 122.53
Net present value (NPV) at 15%	20.38	18.56	127.84	212.46
Internal rate of return (IRR) in %	37.45	35.32	71.28	42.45
Rank based on INV	4	3	2	1
Rank based on IRR	3	4	1	2
Rank based on NPV	3	4	2	1

Note: *Implementation period was not included, while for those of Maharashtra, the implementation period of 5 years was included. INV for Maharashtra watersheds was accordingly adjusted by discounting the cost stream @15%.

Costs, Benefits and Returns to Investment

Table 2 gives the investment and net incremental benefits from the watershed interventions. The incremental incomes from agriculture, agro-horticulture and forestry sectors were considered. Investment in watersheds in Tamil Nadu was a bit below Rs 20 lakh, while in Shedashi-Wavoshi watershed it was the highest at Rs 174 lakh.

The data also shows that the incremental benefits were higher for the watersheds with higher investments. However, Rajani watershed, which was smaller than Shedashi-Wavoshi in terms of investment, had higher IRR. There was also conflict in ranking based on IRR and NPV at 15 per cent discount rate between these two watersheds. A note of caution is required here. The basis for computation of costs and benefits varied across the selected watersheds. The Tamil Nadu study assumed full scale benefits accruing from the first year after the completion of the implementation period. Further, it assumed that the incremental benefits accrue every alternate year. The basis for this assumption was the pattern of rainfall over the years. The Maharashtra studies assumed gradual realisation of incremental benefits from the 4th year (i.e. after spending 50% of the proposed outlay on watershed works), reaching full scale from the 6th year onwards. For this study, we have recomputed the IRR and other related parameters for the Tamil Nadu watersheds by assuming benefits accruing every year. In the case of Maharashtra watershed studies, we have discounted the initial investment spread over 6 years to the initial year. Thus, these estimates differ from those reported in the respective reports in our attempt to impart certain degree of comparability.

Modified Internal Rate of Return (MIRR)

Table 3 presents the basic parameters needed for computing modified IRR measures following the

Table 3. Estimated components for computing the modified IRR

Particulars	Watershed			
	Kattampatti	Kodangipalayam	Rajani	Shedashi-Wavoshi
Time span (n), years	15	15	25	25
Reinvestment rate (k)	0.1	0.1	0.1	0.1
Initial investment (INV)	1939299	1962533	2705685	11155857
NPV @15%	2,038,097	1,855,551	12,783,803	21,246,469
INV+NPV	3,977,396	3,818,084	15,489,488	32,402,326
$(1+k)^n$	4.18	4.18	10.83	10.83

Table 4. Estimated modified IRR adjusted

Particulars	Watershed			
	Kattampatti	Kodangipalayam	Rajani	Shedashi-Wavoshi
IRR	37.45	35.32	71.28	42.45
$MIRR_1$ (k= 10%)	15.40	14.99	17.95	14.79
$MIRR_2$ (k= 0%)	4.91	4.54	7.23	4.36
$MIRR_3$ adjusted for scale & time (k= 10%)	10.70	10.65	13.48	15.56
$MIRR_4$ adjusted for scale & time (k=0%)	0.67	0.62	3.10	4.36
Ranking based on				
IRR	3	4	1	2
$MIRR_1$ & $MIRR_2$	2	3	1	4
$MIRR_3$ & $MIRR_4$	3	4	2	1

formulae discussed in the methodology section. There are time span and scale differences between the Tamil Nadu on one hand and the Maharashtra watersheds on the other.

As per the conventional IRR, returns in the Rajani watershed, for example, were Rs 71.28 for every Rs 100 invested. The inherent assumption is that returns obtained year after year are reinvested with an expected return of 71.28 per cent. One can rationally assume 10 per cent (or of similar order) return from yearly returns which we did in this paper. Strictly speaking, since returns from watersheds are accrued to a host of beneficiaries, the absence of reinvestment option is also quite likely. Hence, we also worked out MIRR with k =0. The estimates are presented in Table 4.

The MIRR without adjustment for scale and time span ranged between 14.79 and 17.95 per cent assuming a reinvestment possibility at 10 per cent per annum. This shows that the projects gave more or less comparable returns as opposed to the divergent returns based on the conventional measure of IRR. Also, the study has shown that when adjusted for the scale of investment and time span, MIRR gives a ranking coinciding with the one based on NPV.

A couple of issues need highlighting here. First, the value of rate of return on reinvestment of project's returns was arbitrarily assumed at zero and 10 per cent. It is debatable as to what can be this rate as this rate is crucial in calculating MIRR. Second, the above methodology assumes that the projects are otherwise comparable. Based on the review of a few watershed evaluation studies and available reviews, we feel that no two studies can be compared mainly due to differential procedures and assumptions. Construction of cash flow statement has been quite different studies. For example, some studies assumed benefits from the first year after the implementation was completed, while a few other studies assumed some benefits to accrue once certain amount of investment outlay was spent and reached full scale when the implementation was complete. Needless to say, the composition of benefits also varies widely. The studies have also varied in respect of time span of cash flows. It may be noted that even when capital rationing is not an issue, projects are still compared in some context or the other. Such comparisons may lead to erroneous stereotyping if they are not comparable. Hence, there is a need to follow broad but common evaluation assumptions and procedures.

Summary and Conclusions

The study has demonstrated the use of modified IRR in developmental projects, by using the data pertaining to four watersheds — two from Tamil Nadu and two from Maharashtra. The conventional internal rate of return (IRR) widely used in project evaluation, suffers from certain problems, most important one being the assumption of reinvestment at the rate of IRR which has been often contested in project evaluation literature. The ranking of projects based on IRR and NPV may also come into conflict due to this assumption. Scale and time span differences across projects often make it difficult to compare. In India, the use of conventional IRR still prevails even though improvements have been suggested in literature long ago. The application of modified IRR method coupled with adjustment for scale and time span differences suggested in the literature has been demonstrated in this paper using data for four watersheds. The results have shown that the rate of return from investment watershed is less lucrative when MIRR is used with necessary adjustments for scale and time span and the rankings based on IRR and NPV are consistent.

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