JJMIE

Volume 5, Number 2, April 2011
ISSN 1995-6665
Pages 193 - 196

Jordan Journal of Mechanical and Industrial Engineering

# Decision Making Using Multiple Rates of Return: An Alternative Approach

Ahmad Jaradat [a,*] and Khaldoun K. Tahboub[b]

[a] Industrial Engineering Department, Faculty of Engineering & Technology, University of Jordan, Amman, Jordan.

[b] Mechanical and Industrial Engineering Department, Faculty of Engineering, Applied Science University, Amman, Jordan. On leave from Industrial Engineering Department, University of Jordan.

**Abstract**

Internal rate of return (IROR) method as a decision making tool receives widespread use and acceptance in economic analysis. When performing economic analysis using IROR method, multiple rates might exist, in such cases these rates might be misleading. This research aims at presenting a realistic approach for resolving the multiple rate of return (MROR) problem. A Proposed approach is presented and illustrated through demonstrative cases. The key advantage of the proposed approach is that it reflects real life opportunities and its decisions are consistent with worth methods as well as with other approaches. Relevant approaches of well-known authors are presented discussed and critiqued.



**Keywords**: Internal rate of return, external reinvestment rate, return on internal investment, and multiple rates of return.

## 1. Introduction

Economic analysis is inevitably an important tool in the decision making process. One engineering economy aspect is devoted to decision making among alternatives. When comparing mutually exclusive alternatives, the main commonly methods used as a basis for comparison are worth methods such as present worth (PW), annual worth (AW), and future worth (FW). Except for the payback period method, other methods such as PW, AW, FW, rate of return (ROR), and benefit-cost ratio (B/C) provide consistent results in terms of the best decision. These methods are widely used but with different preferences in organizations of different forms and types since each method has its own merits of advantages and disadvantages.

The main advantage of worth methods is that they are an absolute measure of investment. On the contrary, ROR and B/C ratio methods ignore the scale of investment and each is used only as an index for profitability in making the accept/reject decisions. This explains why worth methods are applicable on both total and incremental basis, while both ROR and B/C ratio are applicable only on incremental basis.

The key advantage of the ROR method is its widespread acceptance by industry [1, 2]. Decision makers and financial managers prefer ROR analysis to PW method because they find it intuitively more appealing to analyze investments in terms of percentage ROR rather than in PW [3]. This paper aims at presenting a practical solution to the multiple rate of return (MROR) problem taking into consideration real life practices.

## 2. Literature Review

Although some difficulties are encountered in solving certain types of cash flows for ROR, it is the most widely used method that has wide acceptance and preference especially in industry and business sectors; it is intuitively appealing and understood.

There are several definitions for ROR, however, all are the same in spirit, since the same set of equations are used in solving for ROR; net worth of cash flow ( $i*$ ) = 0. The first is a mathematical definition: ROR is the breakeven interest rate $i*$, which makes the worth of cash outflows equal to the worth of cash inflows of the same project.

The second definition is concerned with loan transactions: ROR is the interest paid on the unpaid balance of a loan such that the payment schedule making the unpaid loan balance equal to zero when the final payment is made. This always complies with reality, and its cash flow has a single internal ROR (IROR) simply because loan transactions are based upon a predefined and agreed (contracted) interest rate usually minimum attractive rate of return (MARR) for the lender paid on the unpaid balance of the loan.

* Corresponding author. Jaradat_ahmad@yahoo.com

The third definition is concerned with project return: ROR is the interest rate charged on the un-recovered project balance of the investment such that, when the project terminates, the un-recovered project balance will be zero [3, 4]. This definition is not always consistent with reality, simply because projects' cash flows are mainly based upon feasibility studies and future expectations or contracts rather than a predefined or agreed upon interest rate, where cash flows may reverse signs more than once, which explains the possibility that MROR might exist.

The major difficulty encountered with the ROR method is the occurrence of MROR. Different authors presented different perspectives about MROR. When there are MROR, none of them should be considered a suitable measure for the ROR or attractiveness of the cash flow [5]. MROR are not meaningful for decision making purposes, it is likely that none is correct [1, 2], some of the MROR values seem ridiculous and difficult to use in practical decision making [6]. MROR fail to provide an appropriate measure of profitability for an investment project [3], controversial [7], constitute severe drawbacks [8], unreasonable [9], and there is no rational means for judging which of them is most appropriate for determining economic desirability [10]. In [11, 12] contrary to previous consensus, stated that MROR, even complex-valued each has a meaningful interpretation as a ROR. Next, a new approach for dealing with MROR is presented.

## 3. Methodology

External reinvestment rate (EIR) is the interest rate at which released (receipts) money from the project over its life can be reinvested. The reinvestment rate in reality represents the opportunity cost usually MARR. "EIR is the interest rate at which the money can in fact be invested outside the project" [4].

The key point of the proposed methodology is based on calculating the return on actual capital portions that remain invested internally, while cash released (receipts) from the project is reinvested externally at EIR. The following represent the steps of the proposed approach:

**Step 1**

All positive cash flows (released money) that are followed by the first negative cash flow, say at the end of period (m) are invested at EIR to be returned to the project at the end of period (m).

**Step 2**

If the compound amount at the end of period (m) resulting from step 1 is negative, then the negative value indicates that it is a portion of invested capital, and remains negative at that point of time. But if the compound amount is positive, then it will be invested again at EIR with the next negative value of cash flow since it represents actual money at hand (released money).

**Step 3**

Step 1 and step 2 are repeated until there are no more negative cash flows that are preceded by positive cash flows.

**Step 4**

All remaining positive cash flows that are preceded by negative cash flows are invested at the reinvestment rate and compounded with the last positive cash flow in the project. Now, the project cash flow has either no sign changes or only one sign change. If the cash flow has no sign changes, it means that there is no ROR.

**Step 5**

Solve the modified cash flow for (i*).

## 4. Case Studies

Ten cases will be studied and compared with other known approaches. The first case is next discussed in detail. The same analysis applies for all others.

Consider the following CF and assume that the received money from the project earns 10% interest, i.e. MARR is 10 %. This CF has three sign changes, hence, MROR might exist.

Table 1: Cash flow for 1st case.

| EOY | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **CF** | - 75 | 250 | - 100 | - 500 | 400 | 150 |

As discussed earlier, positive CF at EOY 1 of 250, is reinvested to EOY 2 using EIR of 10%. This available fund is returned to the project at the EOY 2. Hence, the compound amount at the EOY 2 equals {$250\times(F/P,\ 10\%,\ 1)-100$}, which is + 175.

Now, the available +175 will be reinvested again externally at EIR of 10 % to be returned to the project at the EOY 3. The compound amount at EOY 3 equals {$175\times(F/P,\ 10\%,\ 1)-500$}, which is $-307.5$. The negative sign indicates that the amount $-307.5$ is a portion of the invested capital.

At EOY 4, available funds released from the project, i.e. 400, will be externally invested at EIR of 10 % to EOY 5. Compound amount at EOY 5 is equal to {$400\times(F/P,10\%,1)+150$}, which is $590$. Now the modified cash flow has one sign change, which means that there exists either zero or one positive ROR.

Table 2: Modified cash flow for 1st case.

| EOY | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **CF** | - 75 | 0 | 0 | -307.5 | 0 | 590 |

Solving for $i^* \cong 16.94\%$. Comparison of this result with [1, 3-5] is shown in Table (3):

Table 3: Comparison of results for the 1st cash flow.

| No. | Approach | *i** % |
|---|---|---|
| 1 | proposed | 16.94 |
| 2 | Newnan | 17.41 |
| 3 | Sullivan | 12.14 |
| 4 | Park | 25.60 |

Table 4 shows the cash flows for all cases along with the 1st case.

Table 4: Cash flows for the ten cases using the proposed approach.

| CF No. | EOY | | | | | | | | | | | | | EIR% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | |
| 1 | -75 | 250 | -100 | -500 | 400 | 150 | - | - | - | - | - | - | - | 10 |
| 2 | 30 | -60 | 50 | -80 | 20 | 70 | - | - | - | - | - | - | - | 10 |
| 3 | -40 | 30 | 22.5 | 15 | 7.5 | 0 | -7.5 | -15 | -22.5 | - | - | - | - | 12 |
| 4 | 20 | 60 | -100 | -100 | 0 | 50 | 60 | 0 | -150 | 100 | 130 | - | - | 6 |
| 5 | 50 | - 80 | 100 | 0 | -300 | 0 | 150 | 0 | 200 | 0 | -30 | 0 | -50 | 10 |
| 6 | -500 | 300 | 300 | 300 | -600 | 200 | 135.66 | - | - | - | - | - | - | 6 |
| 7 | 0 | 100 | 200 | -600 | -200 | 300 | 300 | -50 | - | - | - | - | - | 15 |
| 8 | -100 | 330 | -362 | 132 | - | - | - | - | - | - | - | - | - | 12 |
| 9 | -100 | 380 | -527 | 313 | -66 | - | - | - | - | - | - | - | - | 15 |
| 10 | 20 | 60 | -100 | -100 | 0 | 50 | 60 | 0 | -150 | 100 | 130 | - | - | 15 |

## 5. Discussions

The proposed approach provides realistic results when compared with other known approaches. It is based upon a simple real life practiced fact that cash released (generated) from the project is reinvested externally at the best available rate at that time which is the EIR (usually MARR) since it is actual cash money at hand with the investor, and returned to the project (wholly or partially) when needed. In this approach the true IROR on money actually invested in the project is computed.

Worth methods assume implicitly that both cash outflows and inflows are reinvested at MARR during the study period, while *ROR method* assumes that both cash outflows and inflows are reinvested at *IROR,* which might not be realistic for some problems, hence may not be valid. The reinvestment assumption of the IROR method noted previously may not be valid in an engineering economy study [1, 2]. There can be no particular reason why we would assume that the external investments earn the same ROR as internal investments [4, 5]. In reality, it is not always possible for cash borrowed (released) from a project to be reinvested to yield a rate ROR equal to that received from the project [3]. Table (5) shows comparison results of the proposed approach with [2-4].

Table 5: Comparison of proposed approach results with others.

| Approach | i* *% for the different cash flows* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** | ***7*** | ***8*** | ***9*** | ***10*** |
| **proposed** | **16.94** | **20.00** | **12.17** | **8.87** | **10.27** | **8.40** | **13.72** | **12.00** | **15.00** | **13.31** |
| Newnan | 17.41 | 20.90 | 13.03 | 9.081 | 10.67 | 11.10 | 12.73 | 12.00 | 15.00 | 13.15 |
| Sullivan | 12.14 | 12.53 | 12.12 | 6.804 | 9.73 | 7.26 | 14.67 | 12.00 | 15.00 | 14.58 |
| Park | 25.6 | 23.90 | 13.03 | 9.081 | 11.35 | 13.13 | 12.73 | 12.00 | 15.00 | 12.41 |

In finding (i*), Table (5), [3] discounted the project balance (PB) if positive at MARR, while discounting PB if negative at IROR even though the cash flow may be positive at that time. This might not always be realistic simply because PB is not an available fund at hand of the investor. A realistic case that complies with this approach is loan transactions, not because the approach itself, but because of the nature of loan transactions where it is contracted in real life on the basis of a predefined (agreed upon) interest rate that should be paid on the unpaid balance also because of the stability of the interest rate being agreed upon. [4, 5] approaches in essence are the same as [3], though different expressions and terminology have been used, hence, same comments apply.

In [1, 2] approach for finding (i*), Table (5), all cash receipts from the project are compounded to period N (the future) at EIR, ignoring the possibility that some of these funds may be returned to the project when needed. Also, all disbursements are compounded to time zero (the present) at EIR, again ignoring the fact that some of these disbursements (or portions) should be discounted at IROR and not at EIR. Next, solving the resulting balanced CF for ERR to be compared with firm's MARR in making the accept/reject decision, which might not comply with real life opportunities. If a firm needs to know what ROR will be achieved it is unclear what does the calculated ERR represents in reality. The main advantage of his approach is that it always has a single ERR that works as an index for profitability and consistent with worth methods in making the accept/reject decision.

## 6. Conclusions

ROR method is a powerful tool in making accept /reject decisions. The term ROR is intuitively appealing and understood and has widespread acceptance in business and organizations. It is routinely used in daily financial transactions.

The proposed approach is reliable, and reflects the real life opportunities simply because it calculates the return on actual capital portions that remain invested internally while cash released from the project is reinvested externally at the only available rate (real life) at that point of time which is the EIR.

So the proposed approach presents more than a mathematical solution or remedy; hence the calculated ROR is reliable, trusted and beside its simplicity, its decisions are always consistent with worth methods as well as with other approaches.

Even projects that have a single ROR, the proposed approach can be applied since it completely consistent with real life practices.

## References

[1] Sullivan, W. G.; Wicks E. M.; and Luxhoj, J. T., Engineering Economy, 13th Edition. Prentice-Hall, New Jersey, 2006.

[2] Sulivan, W.G., Wicks, E.M., and Koelling, C.P., Engineering Economy, 14th ed., Prentice-Hall, 2009.

[3] Park, C. S., Contemporary Engineering Economics, 3rd Edition. Prentice-Hall, New Jersey, 2010.

[4] Newnan, D.G., Whittaker, J., Eschenbach, T.G., and Lavelle, J.P., Engineering Economic Analysis, Engineering Press, 2nd Canadian ed., 2010.

[5] Newnan, D. G., Engineering Economic Analysis, 6th Edition. Engineering Press, San Jose, California, 2004.

[6] Blank, L. T. and Tarquin, A. J., Engineering Economy, 5th Edition. McGraw-Hill, New York, 2005.

[7] Steiner, H. M., Engineering Economic Principles, 2nd Edition. McGraw-Hill, New York, 1992.

[8] White, J. A.; Case, K. E.; Pratt, D. B.; and Agee, M. H., Principles of Engineering, Economic Analysis, Wiley, New York, 1998.

[9] Cannaday, R. E.; Colwell, P. F.; and Paley, H., "Relevant and Irrelevant Internal Rates of Return. Engineering Economist, Vol. 32, pp. 17-38, 1986.

[10] Thuesen, G. J. and Fabrycky W. J., Engineering Economy, 9th Edition. Prentice-Hall, Englewood Cliffs, New Jersey, 2001.

[11] Hazen, G. B., A new Perspective on Multiple Internal Rates of Return. The Engineering Economist, Vol. 48, pp. 31-51, 2003.

[12] Hartman, J.C. and Schafrick, IC., The Relevant Internal Rate of Return, Engineering Economist, summer 2004.