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On Misunderstandings in Project Economic Evaluation Theory

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Abstract: *This article proves that IRR does not conform to the economic meaning of marginal income from the perspective of theory and practical application. Only the net present value rate NPVR and the net investment return rate N/K conform to the economic meaning of marginal income. This also theoretically explains why the use of IRR sorting cannot guarantee the optimal portfolio of selected projects when funding constraints do not cut projects. Therefore, the use of index rankings other than NPVR or N/K lacks theoretical basis and can only be an approximate method in practical applications.*

Keywords: *Marginal income; internal rate of return; net present value rate; net investment rate of return; capital constraints*

1. Introduction

The economic evaluation theories of investment projects, including Western engineering economics, Japanese economic engineering, and my country's technical economics, usually use the marginal return—marginal cost method to determine the optimal scale of investment projects or the lowest attractive rate of return MARR, in the literature, uses a method similar to the diagram to determine the optimal scale and IRR of an investment project. In the figure, the abscissa represents the cumulative value of investment, and the ordinate represents the marginal revenue and marginal cost. Use IRR to represent the marginal revenue of the project, and MARR to represent the marginal cost of the project. According to the basic principles of economics, when MARR, the profit of the project is gradually increased; when IRR, the profit of the project is gradually reduced; when IRR, the profit of the project reaches the maximum point and maximizes the profit Goal, the investment reaches the optimal scale of total amount. At this time, the discount rate determined by the intersection of IRR and MARR is the MARR of the project. When there are capital constraints, such as the capital constraint IRR in the figure, although it cannot be reached at this time, it can be guaranteed[1-3] .

2. Proof of the problem

First, let's look at the definition of internal rate of return. The so-called internal rate of return refers to the discount rate that makes the net present value of net cash flow equal to zero. Its expression is:

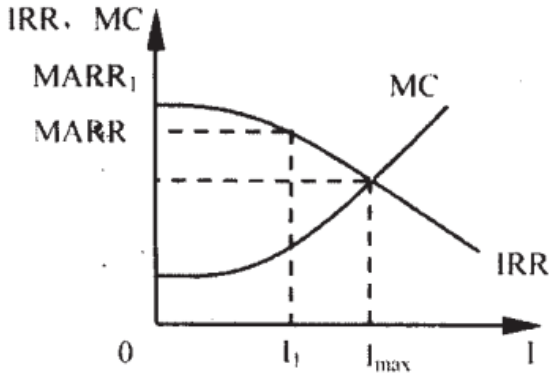

Figure 1. The optimal investment scale of the project

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$$NPV(IRR)=\sum_{t=0}^{n}(CI-CO)_t(1+IRR)^{-t}=0$$

Among them, CI is the inflow of cash, CO is the outflow of cash, and N is the life of the project. From the definition of IRR, it can be seen that the economic meaning of IRR is: Calculated by IRR during the entire life of the project, there will always be unrecovered investment, and at the end of the life, the investment will be fully recovered. In other words, during the life of the project, the project is always in a state of "paying off" the unrecovered investment. Therefore, the expression of another economic meaning of the internal rate of return is that it is the profit rate of investment that is not recovered during the life of the project. It is not the profit rate of the initial investment during the entire life of the project. It is also affected by the size of the net income of each year during the life of the project. Under this interest rate, at the end of the project's life, the project will recover all the investment with the annual net income. It is the overall rate of return of a project. The expression of the rate of return is a special discount rate that reflects the rate of appreciation of funds in the project. Therefore, IRR does not reflect the profitability of unit funds and cannot calculate the initial investment rate of return. The concept of project marginal revenue refers to the increase in revenue for each additional unit of investment project. Note that the income here refers to the net present value of the project, because the behavior of the project to maximize profit is reflected in the index as the net present value[4-6].

From the above definition of IRR, it can be seen that IRR does not indicate the level of return on unit investment. Therefore, using IRR as marginal return is not in line with the concept of marginal return. If IRR can be used as a marginal benefit, then when the capital constraint does not cut the project, there is no interference from the indivisibility of the project at this time, and it is certain that the selected project portfolio can be guaranteed to be the optimal combination, but can IRR guarantee that this conclusion is reached? Let's use a simple example to illustrate this problem. Example: There are three independent investment projects with a life span of 0 years, a benchmark rate of return of 10%, and a capital constraint of 100,000 yuan. The project data are as follows:

Table 1. Net cash flow statement of investment projects

	0	1	2	3	4	5
A	−10	4	3	4	2	4
B	−7	2	3	3	2	1.9
C	−3	1	1	1	1.1	1.1

From the above analysis, it can be seen that whether IRR is used as a concept of project marginal revenue, whether from theoretical or actual evaluation, it is problematic and does not meet the economic meaning of marginal revenue. Therefore, under the condition of capital constraints, using IRR to sort the best, whether in theory or in practice, cannot guarantee that the selected project portfolio must be the best combination. At the same time, from this perspective, it also theoretically explains the ranking method of other indicators that do not reflect the level of return on unit investment. Like net present value NPV, cost-benefit ratio B/C, and IRR, they cannot be used as marginal income. Concept, regardless of whether there are financial constraints, there is no guarantee that the result will be optimal[7-9].

$$NPVR(i_c)=\frac{NPV(i_c)}{I_P}$$

Where I_p is the sum of the present value of the investment.

3. NPVR evaluation criteria

When NPVR is greater than 0, the project can be considered economically; when NPVR is less than 0, the project can be considered economically to reject the project. From the definition of the indicator, it can be seen that NPVR reflects the level of return on unit investment, and NPVR is the most consistent indicator of the economic meaning of marginal returns. Therefore, when funding constraints do not cut projects, the project portfolio selected according to the NPVR ranking must be the optimal project

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portfolio. If the vertical axis of Figure 1 represents the NPVR of the project, the marginal cost at this time is zero, and the horizontal axis of the coordinate is not IRR, then the area enclosed by the NPVR curve and the horizontal axis is 1/3 of the entire project, which can guarantee the selection The project portfolio is optimal. However, in actual project evaluation, when funding constraints cut the project, due to the indivisibility of the project, the use of NPVR sorting may not guarantee the optimal results.

Another indicator similar to the net present value rate NPVR is the net investment return rate N/K. The net investment return rate is the current value of the investment and the current value of the project net income and N/K are defined as follows:

$$N/K(i_c)=\frac{\sum_j N_j(1+i_c)^{-1}}{\sum_j K_j(1+i_c)^{-1}}$$

Where Nj is the net investment income of the project in year j, and Kj is the investment in year j of the project.

The numerical difference between N/K and NPVR is only one, and the conclusions of N/K ranking and NPVR ranking are completely consistent. Although the N/K indicator cannot directly represent the level of return of unit investment, it can indirectly reflect this economic meaning, and therefore, it can also be used as the concept of marginal revenue. N/K is the same as NPVR. When capital constraints do not cut projects, it can ensure that the selected project portfolio is the optimal combination; when capital constraints cut projects, it cannot guarantee that the selected project combination must be the optimal combination.

However, when these two indicators are used as marginal returns, they do not have the advantages of IRR. The determination of these two indicators requires the determination of the benchmark rate of return in advance. When the benchmark rate of return is determined, there is no problem in using these two indicators; when the benchmark rate of return is changing, the use of these two indicators is restricted. In practical applications, due to the different financing costs of different funds and the different required profit rates, etc., it is often that the benchmark rate of return increases with the increase of funds raised. Therefore, these two indicators are in It is greatly restricted in practical applications.

4. Conclusion

In the economic evaluation of investment projects, the definition formulas of IRR, NPVR, and N/K indicators can prove that all these indicators are completely equivalent to the evaluation of a single project. As long as the indicators exceed the prescribed standards, the NPVR of the project can be guaranteed It is greater than zero, so it can be used to determine the optimal investment scale of the project under the condition of unconstrained funds. On the surface, it seems to be in line with the economic meaning of the project's marginal income, but it is not. Both NPVR and IRR indicators do not conform to the economic meaning of marginal revenue, and can only be used as marginal revenue. At this time, the marginal cost of the project is zero and one respectively.

This theoretically explains why the use of all indicators other than N/K or NPVR cannot guarantee the optimal portfolio of selected projects when funding constraints do not cut projects. In the actual project selection, coupled with the indivisibility of the project, it is even more difficult to ensure the best results. Therefore, strictly speaking, N/K, NPVR and IRR ranking cannot be used for project selection. The use of these index rankings is at most an approximate method, and their use lacks theoretical basis.

However, the use of NPVR and N/K is limited by the determination of the benchmark rate of return, and at the same time, the optimal results may not be guaranteed when the capital constraint cuts the project, so the use of actual project evaluation is greatly restricted.

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