Comparative Analysis of Different Investment Decision Indicators: NPV and PI

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Abstract: Decision-making index is one of the key topics in today's research. Researchers have separately analyzed different investment decision indicators, but still lack comparative analysis. Therefore, this study compares NPV and PI, and analyzes their formulas, economic significance, advantages and disadvantages. The research results show that NPV and PI have the common shortcomings of the discount rates because of the similar calculation methods. For example, they need to determine the discount rates in advance and cannot compare items with different discount rates. When they are used, they will encounter difficulties in calculating the discount rates. In addition, although NPV has a wide range of applications and can be applied to a variety of situations, and the calculation method is relatively perfect, NPV is still due to the comparison of projects with inconsistent length and duration, and it not applicable to the comparative decision of independent investment schemes. The advantage of PI is that it can reflect the efficiency of investment, but relatively it also loses the ability to reflect the actual income level of the project. In actual decision-making, NPV can be used to determine the investable projects before PI is used to rank the projects under the condition of insufficient funds to ensure the full use of funds.

Keywords: NPV, PI, investment decision

1. Introduction

Project investment decision-making is an inevitable process in the process of enterprise investment, which is especially significant to the development of companies and the development of countries' economy. In the research of project investment decision-making, there are many literatures comparing different evaluation indexes, and revealing their advantages and limitations [1-4]. Graham and Harvey studied the characteristics of NPV, and considered that NPV is an excellent indicator to measure whether the investment is worthwhile, especially widely used by large companies [5]. Brounenn proves the same point [6]. It can also be used as a basis of uncertainty evaluation [7]. Joan Pasqual, Emilio Padilla and Evans Jadotte compared many popular evaluation indexes, which concludes net fifinal value, benefifit–cost ratio, profifitability index (PI), and other indicators [8]. And finally they find that it is important to discover if their result is equivalent to NPV or if they can be more useful. Qiuli Wang compared and analyzed the application of NPV method, profitability index method and IRR method, and came to the conclusion that NPV is a better evaluation method, but PI may be better than NPV in the specific case of insufficient funds. Previous studies only

analyzed different investment decision-making indicators separately or compared various indicators, but the description of each indicator was not detailed enough [9]. Therefore, this paper chose NPV and PI to analyze and compare them separately. This research is helpful to enrich the theoretical literature of investment decision indicators. The remaining of this study is organized as follows, section 2 will focus on the detailed description of the NPV method, including the calculation method and evaluation standard of NPV and the calculation of discount rate, which is a very important data in NPV calculation. Then, examples will be given to illustrate the use of NPV. Section 3 will introduce the profitability index in detail, including the calculation method, evaluation index and examples. Section 4 will compare NPV and PI indicators, compare their respective advantages and disadvantages, and on this basis, study how to comprehensively apply the two indicators in practical application to avoid their disadvantages.

2. Description of Net Present Value

2.1. Introduction of Net Present Value

The net present value is used to assess investment projects. NPV is generated because the investor needs to convert the revenue of each program to the same time point to calculate their profit. This method uses the present value of cash outflow minus the total present value of net cash inflow to get a result, which is called NPV. After that, the investment plan will be assessed based on the outcome of NPV.

The NPV function is as follows:

$$NPV = \sum \frac{It}{1+R} - \sum \frac{Ot}{1+R} \tag{1}$$

NPV- net present value; It- cash inflow in the t year; Ot- cash outflow in the t year; R- discount rate; N- Life cycle of investment project.

2.2. Decision Criteria

If NPV>0, it means that the revenue of investment is higher than the cost of capital, and the project is worth investing in.

If NPV=0, it indicates that the amount of money that investors can earn from the investment of the project is equal to the cost of capital, and whether to invest in the project needs comprehensive analysis.

If NPV<0, it means that the investment in this project is at a loss and should be rejected.

When the NPV of multiple projects is greater than 0, the project with high NPV is preferred for investment.

2.3. Discount Rate

When using NPV, the biggest difficulty for the company is to determine the discount rate. Discount rate is the ratio that change the expected future income with a limited period into the present value. The discount rate is affected by many factors, including capital cost, capital supply and demand, investment risk and inflation.

In practice, the discount rate can be selected by machine according to the following formula:

Discount rate = risk-free rate of return+market average rate of return-risk-free rate of return.

2.4. Example of NPV

The discount rate is supposed to be 10%.

Now there are two projects with an initial investment of 1 million dollars. Project A will get a return of 300,000 dollars per year in the next five years, while Project B won't get any return in the next five years in the first three years, but will get a return of 750,000 dollars per year in the fourth and fifth years. If we don't consider the time value of money, we can find that their total investment is equal, both of which are 1 million, and their total income is equal, both of which are 1.5 million dollars, and their returns are higher than their initial investment, but this is actually not the case. If you want to use NPV method to calculate, you should first discount the cash flow of each year to the first year for comparison. The calculation method is to divide the cash flow by 1 plus the nth power of the discount rate, and the number n is determined by the number of years. For example, when calculating the discount value of the second year's cash flow, n=2, when calculating the discount value of the third year's cash flow, n=3, and so on.

In the end, the discounted value of each year is added, and then the initial investment amount is subtracted, which is the NPV. According to the calculation, the net present value of Project A is 137,200 dollars, and that of Project B is -22,000 dollars. Because the NPV of Project B is less than 0, the company should not choose Project B when making investment decisions.

If there is project C at this time, like project B, there is no income in the first three years, and the annual income is 900,000 dollars in the fourth and fifth years. It can be calculated that the net present value of C is 17.35. At this time, the company should give priority to C when making investment decisions, because the NPV of C is greater than that of A. When the initial investment amount is equal, the return of C is higher than that of A.

3. Description of Profitability Index (PI)

3.1. Introduction of Profitability Index

Profitability index is a method which is widely used to assess the time value of money that can also be employed to estimate the budget of a company. The profitability index uses the ratio of the present value of future cash inflows andr the amount of initial investment to calculate.

The PI function is as follows:

$$Profitability\ Index(PI) = \frac{present\ value\ of\ future\ cash\ flow}{initial\ investment} = 1 + \frac{net\ present\ value}{initial\ investment} \qquad (2)$$

The PI reflects the net present profit that each dollar of initial investment can get, which measures the profitability efficiency of a project.

3.2. Decision Criteria

When PI>1, it means that the PV of future income of the investment project is greater than or is the same as the present value of cash outflow, and the project can be adopted.

When the PI of multiple projects is higher than 1, the project with high PI is preferred for investment.

3.3. Example of Profitability Index

The discount rate is supposed to be 12%.

The initial investment of project A is 200,000 dollars, the income of the first year is 700,000 dollars, and the income of the second year is 100,000 dollars. First, the cash flow of project A is

discounted, and the discount method is the same as NPV, so the present value of project A is 70.5. After that, according to the calculation formula of PI, divide the present value of Project A by the initial investment of Project A to get the PI of Project A, that is, 3.53, which is greater than one. Therefore, the return of Project A is higher than the investment, and it is worth investing in.

The initial investment of Project B is 100,000 dollars, the return in the first year is 150,000 dollars, and the return in the second year is 400,000 dollars. According to the same method, the PV of Project B is calculated to be 453,000 dollars, and the PI is 4.53. The PI value of project B is also greater than 1, and it is also a worthwhile investment project. Meanwhile, compared with Project A, Project B has a higher PI, so it can be concluded that Project B is more profitable than Project A. According to the PI value, the company should give priority to Project B for investment. However, if the NPV of the two projects is calculated at this time, it can be concluded that the NPV of Project A is 50.5, while that of Project B is 35.3. Therefore, according to the NPV, the company should give priority to the investment of Project A.

When the conclusions drawn by PI and NPV conflict, we should find the difference between the two projects and get project A-B with an initial investment of 100,000 dollars, an annual income of 550,000 dollars in the first year and an expenditure of 300,000 dollars in the second year, and calculate the PI and NPV of the new project. The PI of the new project is 2.52, which is greater than 1, and the NPV is 15.2, which is greater than 0. Therefore, the new project is worth investing in, so it can be concluded that project A should be given priority.

4. Comparison of NPV and PI

The advantages and disadvantages of comparing NPV and PI in this study are shown in Table 1.

Table 1: The advantages and disadvantages of NPV and PI.

	advantages	disadvantages
NPV	1. widely applicable and relatively perfect 2. strong adaptability	1.not applicable to the comparative decision of independent investment schemes 2. Different discount rates will lead to incomparable items. 3. It requires the discount rate to be calculated in advance. 4. It requires that the duration of the compared projects must be consistent.
PI	1. reflects the efficiency of investment	1. it can't reflect the actual income level of the project.

4.1. The Advantages and Disadvantages of the NPV

The first advantage of the NPV is that it is widely accepted and the theory is relatively closer to reality. The reason is that it takes the time value of capital into the formula.　The second is that it can be widely applied to various scenarios. The discount rate in the formula contains the necessary rate of return. Therefore, according to its calculation results, the company can independently judge the investment risk.

The first shortcoming of NPV is that it can't be used to compare projects with various initial investment, because NPV calculates a numerical value, not a proportion, so when the investment amounts are different, the results obtained by NPV method may be wrong. Secondly, NPV can't be used to compare schemes with different discount rates. When the discount rates of the two schemes are different, their risks are different, and the conclusion drawn by NPV may be misleading. Third, when calculating the net present value, a series of factors such as risks need to be estimated, and a

discount rate should be preset in advance. Long-term investments will be more attractive when the discount rate is lower. For instance, a larger amount of cash flow is discounted at a higher discount rate, which results in a lower value of the investment project and makes the long-term project less attractive for investment. Fourthly, for mutually exclusive investment plans, if the time lengths are different, the NPV of one investment project will have a short life and the NPV of another investment project will be large and the time will be long, which may also cause the NPV cannot be compared.

4.2. The Advantages and Disadvantages of the PI

The advantage of PI is similar to the advantage of NPV, because both of them use the concept of time value. In addition, it is a relative number, which calculates the efficiency of investment, diminishes the difference of initial cash outflow, and facilitates the comparison of project input of different investment scales. As the discount rate is calculated in the same way, PI and NPV have the same disadvantages in discount rate. Another disadvantage of PI is that it can't show the real income of projects.

4.3. Solution

When comparing different schemes, the most effective method is to first compare the NPV of different schemes, screen out all the projects with NPV>0, and then sort them according to the PI of each project to determine the order of investment.

If the conclusions of NPV and PI are opposite in calculation, the difference of initial investment and cash flow of the two projects will be calculated as a new project, and the NPV and PI of the new project will be calculated. If the NPV of the new project is > 0 and the PI of the new project is > 1, it will prove that the new project is also worth investing, and it can be inferred that in the initial two projects, the one with large amount is worth investing; otherwise, if the new project is considered as a bad one.

5. Conclusion

In this paper, different investment decision-making indicators are compared and analyzed. The calculation methods and applicable standards of NPV and PI are mainly analyzed, and the advantages and disadvantages of the two are compared, and the methods that enterprises can use in actual decision-making and how to continue the analysis when the conclusions drawn by the two conflict are drawn.

The main conclusions of this paper are as follows: Firstly, because NPV and PI both consider the time value of money when calculating, and use the discount method to convert the future cash flow to the present time, both indicators have the defects of discount rate, for example, they can't compare items with different discount rates, and the discount rate needs to be determined in advance, and the results are greatly affected by the discount rate. But in reality, it is often extremely difficult to accurately determine the discount rate, because in reality, the calculation of the discount rate has to take into account many factors, and the situation is very complicated, which makes it very difficult to determine the discount rate.

Secondly, when evaluating a project, NPV pays more attention to the actual income of the project, so although it is applicable in most cases, it still can't compare projects with different time lengths and different initial investment amounts. PI pays more attention to the profitability of the project, which can effectively avoid the above problems, but relatively speaking, it is impossible to know the actual income level of the project only through profitability.

Thirdly, usually, the results of NPV and PI are consistent. But sometimes the results of the two projects will be different, because some projects have high actual income but weak profitability, while

others, on the contrary, have strong profitability, but it is difficult to achieve high profits due to less initial investment and other reasons. In this case, the conclusions drawn by NPV and PI are opposite. Therefore, in this case, the incremental calculation method should be used, that is, the difference between different projects should be calculated, and the PI of the difference amount should be calculated. If the difference between two projects can still be rated as a good project as a project, then the project with a large amount of money is worthy of priority investment, and vice versa.

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