

# Analyze and Improvement of NPV and IRR Methods

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**Abstract.** This paper aims to analyze NPV and IRR and find a better way to apply them to decide on investment. The article presents the advantages and disadvantages of the two methods to support analysis based on other research results. After that, the paper uses examples to analyze mathematically how NPV and IRR work together to overcome one of the disadvantages when the other is not able to distinguish the difference between investments. Also, the characteristics of MIRR are another solution to the disadvantages of IRR mentioned in the paper. The conclusion is that NPV and IRR can complement each other's drawbacks, and MIRR can further address their limitations, making them more applicable for analyzing investment projects.

**Keywords:** Net present value, Internal rate of return, Advantages, Disadvantages, Modified internal rate of return.

## 1. Introduction

During investment different kinds of investment have different times, risks, and returns. All the parts that include money are easy to find out, which is larger and which is smaller, but there is one crucial variable: time. Especially for the long investment that a bank or company will choose, it is important to find the best-fit investment. For example, Siziba and Hall's research shows that UK firms are using NPV way more than before, and IRR is followed closely [1]. Also, due to Ryan and Ryan's research in Fortune 1000 companies, firms need to invest more money and are more willing to use NPV and IRR [2].

NPV and IRR are both used to calculate the investment ability. But what is their difference? NPV sounds simple and straight away shows the profit, IRR gives a percentage to compare with the opportunity cost of capital. What is their own characteristic that lets them become so popular in financing decisions? In this paper, I am going to first list their advantages and disadvantages. After that, I analyzed NPV and IRR to try to overcome some disadvantages and find a development strategy to apply them better.

## 2. Concept

### 2.1. Concept of NPV

NPV is Net Present Value; this is a calculation method for future cash flow; it calculates the time value of cash flow and turns it into a current value with a given discount rate. In Gallo's business review, Knight defines NPV as "Net present value is the present value of the cash flows at the required rate of return of your project compared to your initial investment" [3]. The formula for NPV is calculated as

$$NPV = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} \cdots \frac{CF_t}{(1+r)^t}$$

r = Discount rate

C = Cash flow

t = Time

This equation calculates the future cash flow into the present value; every extra year, an extra discount factor is required ( $1/(1+r)$ ). Calculating NPV and getting a positive result is able to recommend this investment is a good choice in this discount rate, and getting a negative result suggests this investment was smaller than the opportunity cost in the capital market.

## 2.2. Concept of IRR

IRR is internal rate of return, it is work on discount cashflow methodology same as NPV. but different to NPV, IRR result in a rate of return, which is meaningless with its own. IRR works as compare itself with a hurdle rate, or base rate in the capital market. In Gallo's business review, Knight define IRR as "The IRR is the rate at which the project breaks even" [4]. The calculation of IRR is to find the discount rate that will cause NPV equal to zero

$$0 = CF_0 + \frac{CF_1}{(1 + IRR_1)} + \frac{CF_2}{(1 + IRR_2)} \dots \frac{CF_t}{(1 + IRR_t)}$$

This equation is to calculate the annual growth rate due to the given cash flow, which is IRR. IRR assumes that the investor will reinvest any future cash flow by a return that is the same as IRR. In this case, the larger the IRR is, if it is larger than the base rate in the capital market, the better that investment is.

## 3. Advantages and Disadvantages

### 3.1. Advantages and disadvantages of NPV

According to Gallo's business review, NPV includes the time value of money, which makes it popular in financial analysis [3]. This is helpful in discounting the future value of every investment that has a different duration and comparing them in the current time. Also, according to Watson's study, NPV includes all the cashflow of the project in its lifetime and shows the profitability of investment clearly [5]. The calculation of NPV is simple, and the result of this method is clear; it makes this method a fast way to help the investor understand if it is profitable or not to invest.

But in real life, NPV is facing many defects that cause people not to use it as a primary method for investment. There are some factors that NPV can't include that may also be important; Beladi's research shows that when a company has a high risk of a shortage in cash flow, research and development investment is not recommended in their investment plan [6]. Weber's paper shows that it is very sensitive to the opportunity cost of the capital market (hurdle rate); a little change would cause a big change in result [7]. There is other research that proves this theory, such as using the weighted average cost of capital as the discount rate to calculate NPV, will lead to a result that is larger than usual [8]. That lets choosing discount rates plays an important role in NPV calculation and may be hard to recognize when using a wrong discount rate. NPV represents the total net value; in real applications, there are some more variables, such as Lin suggested; it is hard to separate the original investment amount from different independent investments, and this results in all the long investments choosing too much [9]. Because NPV considers the time value of money, the result of an investment with longer maturity to pay back but a higher revenue number may be larger than a short investment. But longer investment usually means higher risk.

In conclusion, NPV shows the time value of the cash flow of the entire lifecycle in current value and tells you the net return of the investment to help investors maximize their wealth easily. But NPV is not able to contain other factors such as investment type risk, original investment amount and being affected by a discount factor a lot, and the result might be

### 3.2. Advantages and disadvantages of IRR

Weber mentioned that IRR is also very popular because it results in a rate of return, so it is simple to compare it with another rate of return in the market [7]. For example, the capital market return is a great example to compare with. The larger the IRR is, the higher the profit you can gain from the investment. Yan and Zhang's report shows IRR is helpless when we need to know the size of the investment because it only shows the rate of return and doesn't show the size [10]. In this case, IRR is not able to separate the big and small investment projects, but it might be helpful when multiple different size nonexclusive investments need to compare with each other.

IRR is based on the NPV calculation method, so it is the same as IRR, which includes the time value of the money. However, it is different from NPV; it assumes that all future cash flow will be reinvested at IRR, so the time value of the money is not as accurate as NPV [4]. Usually, it is not possible to find an investment with this high return immediately. Also, the calculation is not simple; you need some tools to help with calculation to maintain speed. IRR could face problems such as more than one result; due to the research Wang, IRR possibly comes out of two or more results when the cash flow change positively and negatively over time [11]. When using IRR, it should be careful that the cash flow of investment should be constant and positive to avoid inaccurate results.

In conclusion, IRR is also simple to use. Comparing it with the hurdle rate can help you find out the percentage of profit you can gain. It can only show the rate of return; it is helpful to compare different investments with different sizes. But If there is some investment with cash flow that changes a lot, it might be inaccurate and not able to be used.

## 4. Improvement

### 4.1. Simultaneously using IRR and NPV

IRR makes it hard to show the size of the investment because IRR results in a rate of return that can't tell the size of the investment. NPV is shown as a number that can reflect some information about the size with IRR together. When the IRR result is similar, the NPV result represents the size of the investment. For example, there are two investments A and B, with a discount rate of 5%:

|   | Year 0 | Year 1 |
|---|--------|--------|
| A | -1000  | +1200  |
| B | -500   | +600   |

$$\text{NPV for A is } -1000 + \frac{1200}{(1+0.05)} = 142.86$$

$$\text{IRR of A is } -1000 + \frac{1200}{(1+IRR)} = 0 ; IRR = \frac{1200}{1000} - 1 = 0.2 = 20\%$$

$$\text{NPV for B is } -500 + \frac{600}{(1+0.05)} = 71.43$$

$$\text{IRR for B is } -500 + \frac{600}{(1+IRR)} = 0 ; IRR = \frac{600}{500} - 1 = 0.2 = 20\%$$

they have same IRR 20%, but A has NPV 142\$ and B only has 71\$ NPV, it is easy to see that when IRR is same, NPV can recognize which investment has a larger size.

But NPV has the same problem; when it comes to the same NPV result, two investments may have a difference in maturity date. In this case, NPV ignores the difference in date, believing the two investments are the same. Analyzing it with IRR could be helpful in finding out more. For example, there are two investments C and D, with a discount rate of 5%:

|   | Year 0 | Year 1 | Year 2 |
|---|--------|--------|--------|
| C | -600   | +840   | 0      |
| D | -600   | 0      | +882   |

$$\text{NPV for C is } -600 + \frac{840}{(1+0.05)} = 200$$

$$\text{IRR for C is } -600 + \frac{840}{(1+IRR)} = 0 ; IRR = \frac{840}{600} - 1 = 0.26 = 40\%$$

$$\text{NPV for D is } -600 + \frac{882}{(1+0.05)^2} = 200$$

$$\text{IRR for D is } -600 + \frac{882}{(1+IRR)^2} = 0 ; IRR = \sqrt[2]{\frac{882}{600}} - 1 = 0.21 = 21\%$$

In this case, two investments are the same in NPV, but the investment with a shorter maturity date has a higher IRR. This means that IRR could help NPV point out that investments require a long time, which usually means higher risk. Mackevičius and Tomaševič's research also came out with the same result: when NPV or IRR is the same between two investments, following the result of the other method is a reasonable choice [12].

For an investment that comes out with the same result in IRR of NPV, that might be very rare in real life. more often, they come out with different results,

#### 4.2. MIRR

MIRR is a modified IRR calculation; it is slightly different from IRR and solves some of its disadvantages. MIRR calculates the future value of cash inflow (FV) and the present value of spending (PV) and uses them as a standard to find MIRR as the rate of return. The equation is

$$PV(1 + MIRR)^n = FV$$

n = number of periods of investment

PV is the sum of the negative cash flow that has been discounted by the financing rate, which means it assumes all the cash flow that is used to invest is borrowed at the finance rate. That means the negative cash flow in the future will be discounted into a smaller present value in this calculation every year from the start of the investment.

FV is the sum of positive cashflow that assumes that all the revenue has immediately been reinvested in the weighted average cost of capital; this means positive cashflow will be considered as future cashflow that has been revenue at the cost of capital every year till the end of the investment.

This improves the IRR assumption that it will be reinvested at the IRR rate, which is usually impossible to complete in real life. The calculation method of MIRR combines all negative cashflow into PV and positive values into FV; it avoids the problem that IRR may face: when there are cashflow changes positive and negative through time, IRR may result in multiple results. Mackevičius and Tomaševič's research suggested that when NPV and IRR are result differently, MIRR result may replace IRR and considered as the better final decision [12]. In future research, it is possible to improve or modify the IRR to help the NPV IRR combination overcome more disadvantages.

#### 5. Conclusion

In this paper, I reveal the concept and equation of NPV and IRR. NPV results in a value, and IRR is a return. I demand to analyze them and find some way to improve the application of those two methods. NPV is simple for calculating the time value of the money, but it for calculating the time value of the money, but it may lead to long-term investment. IRR is also a simple way to decide the profits of investment, but it can't show the size of the investment. Combining NPV and IRR results together, IRR can tell the longer investment and when NPV is the same, and NPV can tell which is a larger investment when the IRR can't compare two investments. Furthermore, MIRR can help IRR avoid the possible multiple outcomes, and when NPV has different results from IRR, it can be helpful in making a final decision. Though there are some issues that are still not solved, MIRR shows it is possible to improve IRR to make the results better.

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