Comparison Between NPV and IRR: Evaluation of Investment

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Abstract. The net present value (NPV) and internal rate of return (IRR) are frequently used criteria for choosing capital investment projects which has been used for long days since they been created. But these two indicators may lead to contrary result in certain situations. This difference caused the debate that last more than a century about which investment deciding methods is better. Naturally, research on the inadequacy of these two methods has also continued for a long time and achieved many results such as a more reliable IRR calculation method - MIRR, the analysis of multiple roots in the IRR calculation in complex cases to determine the final result. This paper gives the brief definitions of NPV and IRR, and how they are calculated. The questions of when to use different investment decision-making methods is also answered in the paper. After that, the advantages and disadvantages of NPV and IRR were analyzed. At the same time, this paper has also fully researched the improvement of the deficiencies of two investment deciding methods. Finally, this paper compares NPV and IRR, and analyzes why these two methods lead to different results in some certain situations and which investment decision methods is relatively better in investment and draw the final conclusion.

Keywords: Net present value; internal rate of return; comparison; investment.

1. Introduction

Net present value (NPV) and internal rate of return (IRR) are two types of most important and widely use investment deciding criteria in finance area. These two criteria are all work under the framework of the discounted cash flow (DCF) model. DCF models are used to forecast future cash flows. The DCF valuation method is appropriate for businesses with volatile dividends but relatively stable cash flow growth.

The DCF model is applied to determine the asset's value by discounting the asset's future free cash flow using a rational discount rate (WACC). This means that the DCF model considers the time value of money invested in the project. If the discounted value exceeds the current price of the asset, it is profitable and can be acquired. If it's lower than the current price, it means the current price is overestimated and should be decided to sell to prevent loss. The DCF model is a conceptually ideal valuation model, adapted to industries with relatively predictable cash flows, such as utilities and telecommunications, but not so well suited to industries with regular and volatile cash flow fluctuations, such as the technology sector. This model's estimation will lead to reduction of the accuracy and confidence to the estimation of the project's value. In practice, because predicting cash flow over the next decade is incredibly hard, the DCF model is rarely utilized as the only valuation method to price investment projects, with easier relative valuation techniques such as the price-earnings ratio being more widely used. This model is the most conservative pricing method, and its result will serve as the bottom line for the target price. A DCF model will assist investors in developing a quantitative estimation on the invested company in long term, in spite of the standards of valuation finally applied to price investment projects.

Although NPV and IRR are all the investment valuation methods under the framework of DCF model, and they all consider the time value of money. With this common, these two methods will lead to the same project valuation ranking result in some cases. These times it can say that the two methods are the same however in some circumstance NPV and IRR will lead to different project valuation ranking outcomes. Difference in ranking results from two methods imply the conflict in choosing the best investment choices and lead to the debate of which one is the better valuation rules. Hirshleifer (1958) shows the deficiencies of the IRR and lead to the academic in favor of the NPV

methods, as well as Lorie and Savage (1955). In 1984, Jensen and Smith summarized the previous paper at the time and come up with the drawback of IRR in 1980s and let their research become part of the most famous finance textbook- Principles of Corporate Finance of that time [1]. However even now the debate continues because in reality most finance institutions are still using IRR as a vital indicators of making investment decisions perhaps because of the ease of comparison, but this situation is not the same as the theory. According to Ryan and Ryan, 76% of Fortune 1000 companies use IRR 75-100% of the time [2]. Inconsistency between reality and theory is a significant reason why the debate over which approach is better, IRR or NPV, still continues till today.

2. Net Present Value

NPV is the present value of cash inflows minus the present value of cash outflows over time [3]. The present value of the subsequent cash flows of investment projects is used in budgeting and investment decision making to assess the profitability of projects. The calculation process is defined as the formula (1). In order to obtain NPV, investors need to estimate the time that the investment project generates cash flows and amount of future cash flows, then assume a discount rate that reflects the cost of capital or the returns available on equivalent projects and discount the cash flow from future value to present value using the discount rate calculated above. Then by adding up the present value of all cash flows generated by the project and subtract the present value needed to invest to get the NPV.

$$NPV = \frac{Cash\ Flow}{(1+i)^t} - Initial\ Investment \quad (1)$$

The present value of the future money flow of investment projects is applied in budgeting planning and decisions in investment making to assess the profitability of potential project. However, a project with a negative NPV will result in a deficit, and investors should avoid investing in such projects. Only the project with positive NPV is worth to be considered. NPV can be utilized to account for the time value of money and to compare the rate of return of various projects. NPV formula is using the discount rate to represent the time value of money. The rate assumed to discount is the most important part of the NPV calculated formula. The existence of a discount rate indicates that the same amount of funds in the future is worth less than the face value. This phenomenon may be caused by the inflation-which can be translated as the decline of the value of money over time or the opportunity cost of capital- Opportunity costs are the potential benefits that a person, investor, or business foregoes when choosing one alternative over another [4]. Different projects have different NPV under the same principal-which can also be called as return on investment (ROI). Generally speaking, safer investment schemes such as treasury bonds and deposits have a lower return on investment. Relatively risky investments such as stocks have a relatively higher return on investment. NPV methods is been widely used in investment decision making because it has many advantages. NPV gives us an intuitive number to simply judge the value of projects. This is so intuitive that even an investor without any financial knowledge can simply make a value judgment through NPV. Besides NPV also has the benefit of stable and easy to calculate. NPV can also be used to make preliminary investment project comparisons. It is obvious that if project A has a NPV of 100$ and project B has a NPV of 1000$ it is better to choose the Project B. But is NPV methods perfect? Here is still another problem-how much money needed to gain such a profit? What if only need to invest 100$ to gain 100$ profit in project A but need to invest 10000$ to gain 1000$ in project B? Here is the disadvantage of the NPV method, it just provides a simple absolute value which can only reflect the value of a project, cannot provide more effective information. For example, how much money the investor needs to invest in the project, how long it will take for the project to cover the cost with the project's profits, and how risky the project is. None of these important investment metrics can be derived from NPV. Besides NPV is difficult to make comparisons between projects because not enough information is provided about the funds invested and requires reliable long-term forecasts.

3. Internal Rate of Return

Due to some shortcomings of NPV, some people have adopted IRR as an alternative investment assessment method. IRR is a technique used in investment evaluation to assess the profitability of investment projects. In a DCF analysis, IRR is a discount rate that makes the NPV of the sum of all cash inflows and outflows equal to zero. The formula that used to calculate NPV will be used to calculate IRR. IRR is not an absolute value instead it is a discount rate that let the investment project's NPV equal to zero. The goal of IRR is to find the discount rate that lets the present value of the sum of future cash inflows equal to the initial principal of the investment.

$$0 = NPV = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0 \quad (2)$$

In the formula (2), the NPV of the project is set to be equal to zero and the equation is solved with the unknown discount rate, the IRR of the project. Since IRR calculation involves the calculation of high powers, the calculation will be complicated, but computers can easily solve this problem. Just like NPV, IRR has an extremely wide range of applications in investment and finance.

IRR can be used in investment decision making, if the IRR of a project is larger than the capital cost of the project, then will generate a positive NPV, so the project is worth considering for investment. If a project's IRR is smaller, then will cause a deficit and need to be excluded from investors' investment list. IRR application results are helpful, unbiased, and independent of the volume of the alternative investment. IRR can also be used to compare projects with varying levels of risk. Unlike NPV, IRR can also reflect the ability of an investment project to resist risks. Risks is everywhere in capital market. Market may change frequently and bring uncertainty to investor. Discount rate may not change in model but in real cases it will change and make the real value of the investment fluctuate. Risk will appear because the present value is calculated using the expected cashflow and discounting rate, so changes in the actual discount rate will affect the final result. IRR can be the maximum of cost of capital such as depreciation or inflation that the project can undertake if this project wants to make profit. The difference between the IRR and discount rate can be seen as the risk resist ability that a project has, the higher the difference, the safer the project. The project that has 10% discount rate and with IRR of 11% is risky because if the discount rate raised by 10% will make this project worth nothing however if a project with the same discount rate and has IRR of 20% the discount rate needs to raise by 100% to make this project valueless and this condition is hard to appear and means this project has better risk resist ability. IRR provides investors with a rate that can help the comparison between different projects with different principals. The higher the IRR means that under same principal the project has a higher return and vice versa.

IRR also has many disadvantages. First of all, IRR is not intuitive enough. IRR is just a ratio. Investors need to have certain financial knowledge to effectively use IRR. In addition, the calculation of IRR is also complicated, and the solution is basically depended on the computer. The most important thing is that the investment evaluation method of IRR sometimes fails. As mentioned above, the calculation of IRR is a higher-order equation - an n-th power equation in which the number of real roots and imaginary roots adds up to n so there is not necessarily only one real root. Table 1 provides an example.

Table 1. Cash flow statement

Years	0	1	2	3
Net cash flows	-100	470	-720	360

In this example, the "broken cashflow series" appears, and the cash flow series that does not appear negative cash flow after the positive cash flow is generally referred to as the "standard cashflow series". A cash flow sequence in which a negative cash flow occurs after the positive cash flow is called a "broken cash flow series". The broken cash flow series will yield multiple roots of the internal IRR equation. After calculation, it can be known that there are 3 IRRs that make the NPV of this example equals to 0, R=20%, R=50%, R=100%. But after inspection, these three R are not the IRR

of this project. The IRR equation's real roots number is generally not greater than the number of times the positive and negative signs of cash flows change. The number of changes in the sign of the net cash flow must be counted when calculating the IRR. If there are multiple times, it is not safe to assume that the discount rate that results in a zero net present value must be the IRR. In addition, IRR assumes that the reinvestment rate of the annual income of the investment project is as high as the obtained IRR. This assumption is difficult to achieve for investment projects with a high IRR and does not conform to the actual situation [5]. The investor's choice of a too high desired profit limit can also result in the rejection of a portion of effective projects [6].

But with further research, some methods for solving these problems have been developed such as MIRR and the methods that can find true IRR among the real roots that generate by the equation. The MIRR assumes reinvesting at the firm's cost of capital and that the initial outlay is financed at the companies' financing cost. most IRR problems can be effectively addressed by MIRR, such as IRR having multiple values if cash flows change from negative to positive multiple times and not accounting for free cash flows between periods [7]. As a result, MIRR more accurately reflects project profitability than traditional IRR, which assumes project reinvested at the IRR itself, not realistic.

4. Comparison

Investment decision-making is a critical component of businesses and enterprises. There are numerous indicators of investment decision-making that must be considered in order to align them with corporate goals, including the time value of money. NPV and IRR are the most commonly applied investment decision-making methods. NPV and IRR methods have many things in common. First, they are both calculated under the DCF model. Second, they both consider the opportunity cost of capital by discounted future cash flows the investment project could generate. In some case the two valuation methods will produce consistent project ranking but under certain circumstance will lead to conflicting investment result [8].

The independent project is an investment project that is not influenced by the investment decisions of other projects. The conclusions of these two methods are consistent for independent projects with no investment limit. Such projects are acceptable if the NPV is greater than zero or the IRR is greater than the project's standard rate of return. Because IRR is the discount rate when the NPV is zero, when IRR exceeds the benchmark rate, the relevant NPV exceeds zero, and when the IRR is smaller than the benchmark rate, the relevant NPV is less than zero. Neither method is incompatible with the other.

Mutually exclusive project is project that once been selected then other projects must be gives up. For unconstrained mutually exclusive projects. The conclusions of the IRR method and the NPV method are different, their discriminative results are prone to conflict. For example, there exist two investment project called A and B with discount rate of 8%, the cashflow of the project is shown below in Table 2.

Table 2. Investment evaluation of project A and B

Time	0	1	2	3	NPV	IRR
Project A	(12000)	7000	9000	11030	10953.50	44.56%
Project B	(12000)	10000	9000	7000	10532.13	55.62%

Through the calculation analysis, it can be obtained that if the NPV method is used, then the project A will be selected, but if the IRR method is used, the investors will choose the project B. In practical application, the conflict in decision-making between the IRR method and the NPV method. This is due to the fact that the two methods make different assumptions about project reinvestment.. IRR method assumes that the net cash flow generated by the project can be reinvested at IRR, which is irrational. Because the internal rate of return is owned by a single project and has no relationship with other projects, the company's future investment projects may not have the same rate of return as the

project. Each project's internal rate of return is different. The internal rate of return's opportunity cost is not always equal. As a result, the project's internal rate of return cannot represent the rate of return on other investment projects. As a result of such assumptions, projects with positive net cash flows benefit earlier [9]. The net present value method is calculated by discounting the project's benchmark rate of return. This means that the project's cash flows and discount rate have the same opportunity cost in any period. It is reasonable to assume that the project's net cash flows can be reinvested at any time.

When the investment amount is restricted. Even if the NPV of all investment projects is positive or the IRR is greater than the benchmark rate of return of the project, it is impossible to select all projects. In order to maximize profits, investors need to choose the best profile to maximize the net present value of the portfolio. If the IRR method is used the process will be complicated and may lead to wrong conclusions [10]. However, if the NPV method is used, the conclusion that the profit maximization is satisfied can be reached without a doubt. It is clear that NPV is a better method than IRR and the results of the NPV method should be used as the criterion when the two results conflict.

5. Conclusion

Although NPV and IRR both make decisions and obtain final results under the DCF model, these two methods can lead to contradictory results under certain conditions (such as mutually exclusive project). Therefore, it is necessary to evaluate the reliability and accuracy of these two methods. IRR is a more widely used metric than NPV in investment project decisions because IRR has the advantage of being easy to compare across projects and IRR can also provide more effective information such as the risk assist ability projects have. The IRR method, on the other hand, assumes that the net cash flow generated by the project can be reinvested at the internal rate of return of the investment project itself, which is difficult to happen in the real world. Although the NPV method has many shortcomings, for example, it does not provide sufficient investment decision information, such as the risk of the project and the capital required to invest in the project, so that the final result can only provide the present value of the project as a reference. Besides with the deepening of research, some solutions to the problems existing in IRR have been obtained, such as the introduction of MIRR and the means to find the real IRR in multiple real roots of higher-order equations. But NPV is still a better indicator for investment decisions making than IRR because The NPV method assumes that the reinvestment rate of cash inflows brought by the project is the cost of capital and fully considers the features that a project's cash flow at any time and the project's discount rate have the same opportunity cost, which assumption is realistic. NPV also has the merit of intuitive and easy to use. The NPV method solves many of the shortcomings of the IRR method, the NPV method is a better investment decision-making method than the IRR method and should be used when the two results are contradictory.

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