Application and Comparison of NPV and IRR Methods in the Company Investment Decision

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ABSTRACT

In order to find out the application conditions of Net Present Value (NPV) and Internal Rate of Return (IRR) in practice, based on previous studies, the paper summarized the advantages and disadvantages of the two methods and explores the specific application conditions in corporate finance. The results showed that the NPV method can reflect the liquidity and overall profitability of investment, provide clear expectations, and be more comprehensive in risk measurement. However, the NPV method could not avoid the problem of cash flow uncertainty. Moreover, the opportunity cost is limited by the project and corporate transparency. It was also found that the IRR method can easily calculate the rate of return on investment and compare it with the industry benchmark return on investment, which has been widely used by practitioners. However, the IRR method may produce multiple values when the cash flow is not a fixed annuity, and the IRR is a ratio that cannot reflect the actual profit. Therefore, several modified NPV and IRR methods were introduced and discussed with their application conditions. In practice, to be noted, there may be inconsistencies between NPV and IRR for investment evaluation. Although both NPV and IRR are effective methods for company investment decisions, it is suggested that, the investment situations should firstly be analyzed before making decision of which methods to be chosen.

Keywords: *Net Present Value, Internal Rate of Return, Advantages, Disadvantages, Company Investment Decision*

1. INTRODUCTION

In the field of company investment, most projects are characterized by long-term and large capital expenditure. In order to reduce projects' investment risk and make correct decision for enterprises, it is necessary to there are some investment decision-making methods, such as Net Present Value (NPV) [1], Internal Rate of Return (IRR) [2], Payback Period (PBP) [3] and so on. Among them, the NPV and IRR methods have been widely utilized in companies' investment decision-making. Recent evidence shows that a number of corporations in the United States and the United Kingdom use IRR more frequently for assessing capital projects, while companies in India and South Africa are increasing their use of NPV [4]. The phenomenon above shows that both ways are extensively recognized as useful and practical methods.

There are many scholars who have used NPV and IRR methods to help companies choose the most feasible project. In the project of oil and gas exploration, Salam et al. used NPV method to demonstrate that the cluster developments could create larger economic benefits [5]. Besides, Diatin et al. successfully selected the project with the poorest financial performance from all the three projects in the catfish farming industry through NPV and IRR methods [6]. Moreover, these two approaches have also been frequently utilized in projects' economic feasibility studies. For example, the application of NPV in the photovoltaic energy storage project proved the economic feasibility of grid parity, and also helped enterprises find the boundary conditions for achieving grid parity within the economically feasible range [7]. There is considerable evidence that the majority of companies choose NPV and IRR to assess the economic feasibility of metal mine projects,

although these two ways ignore the impact of the interaction of uncertainties on the calculation results [8].

Some scholars have also noticed the inconsistency between NPV and IRR methods in the application. The study of Magni and Marchioni suggested that IRR is weakly consistent with NPV [9]. Banerjee found that, when facing two mutually exclusive projects that require different amounts of investment each year, the director of the oil refinery company would obtain contradictory results using NPV and IRR methods [10]. Chen also mentioned that non-conventional projects, such as real estate projects, mineral resources development projects, and some repeatedly investing projects, would lead to decision-making mistakes when applying the traditional IRR rules [11].

Considering the contradictory results by the above two methods, the modified NPV and IRR methods were proposed and applied gradually. Fuzzy Net Present Value [12] was used as a fundamental by Zhang et al. to propose a new evaluation method for a single investment project [13]. Likewise, taking advantage of Decoupled Net Present Value [14] to separate the time value and risk cost, Dou et al. believed that it was more helpful to analyze the economic feasible factors of deep mineral resource exploit projects [15]. Furthermore, Johnston et al. considered that the additional information about the expected finance rate and expected rate of return would be provided by the use of Modified Internal Rate of Return [16,17] in the assessment of the pearl production project [18]. Similarly, Cuthbert and Magni chose the Average Internal Rate of Return [19] to measure performance in Private Finance Initiative schemes [20].

Therefore, this paper aims to clarify the latest application progress of NPV and IRR methods in the company investment decision, and the existing shortcomings and modified versions of the above two methods are also analyzed to provide references for future study.

The remainder of the paper is organized as follows. Section 2 discusses the recent literature on the NPV and IRR while Section 3 presents the application of them and then provides conclusions.

2. LITERATURE REVIEW

2.1. Background of NPV and IRR methods

The concept of Net Present Value was first put forward by Irving Fisher in ‘The Interest of Rate’. According to Irving Fisher, NPV is the difference between the present value of future inflows of funds and the present value of future outflows of funds, which is the basic indicator of the NPV method in project appraisal [1]. The study by Ross suggests that the NPV rules could easily reject a project by considering the factors of capital market alternatives [21]. A noticeable point is that to determine the net present value, future inflows and outflows of funds should be converted to present value by the discount factor of each period. This expected discount rate is determined by the lowest rate of return on investment for the enterprise, which is the minimum acceptable boundary for an enterprise's investment. However, it is undeniable that the NPV rule does have some drawbacks which will be discussed later. In addition, IRR method used to evaluate investment decisions will be presented in this paper. IRR is the discount rate at which the total present value of inflows equals the total present value of outflows and the net present value equals zero. In short, IRR is the rate at which the project breaks even [22]. It is the rate of return that an investment aspires to achieve, and the larger the indicator, the better. In general, if the IRR is greater than or equal to the base rate of return, the project is viable. Kelleher and MacCormack provide more detailed information that three-quarters of CFOs prefer using IRR rules to evaluate capital projects [23]. In the following, we will analyze and present the advantages and disadvantages of using IRR and NPV in detail.

2.2. Advantages and disadvantages of NPV and IRR methods

2.2.1. Advantages of NPV

Many studies have described some benefits of the NPV approach, and this paper will mainly introduce the following four advantages. This includes time value of money, cash flow forecasting logic, investment decision making simplicity, and risk assessment.

In Gollier and Weitzman’s study, one of the benefits of NPV is that it employs discounting as a basic notion, allowing impacts to be compared at multiple future dates by converting each future dollar into equivalent present currency [24]. According to Watson, net present value considers one project’s all cash flows and net revenue throughout the course of a project's life cycle, demonstrating the investment's liquidity and overall profitability [25]. Besides, the NPV method assists investors in making obvious investment choices through a simple formula, suggested by Gaille [25]. Although there is no assurance that an investment will yield the expected return, the information given by this method may be used with to give a pretty clear picture about whether this project can bring value to investors [26]. Furthermore, in the study of Prachi M, systematic risk and industry risk are taken into account via a sophisticated selection and modification of discount rate, making the method more comprehensive in risk measurement [27].

2.2.2. Disadvantages of NPV

In practice, investors find the NPV method challenging to use and therefore do not utilize it as their primary decision-making tool. The unpredictability of cash flow, the sensitivity of the discount rate, the problem of discount rate selection, and the static character of investment decision-making are the major topics of this part.

Because there is no guarantee that the cash flow estimation is completely accurate, the NPV method will always suffer from cash flow uncertainty, rendering the information about determination provided by NPV useless. For example, the study of Beladi et al. showed that great cash flow unpredictability makes businesses less willing to put money into R&D innovation even if the NPV is high [28]. Besides, as Weber's paper shows, the discount rate has better exposure to NPV, thus if a tiny perturbation is introduced to the hurdle rate, the changes are usually unpredictable [29]. Moreover, since the size of the discount rate will directly affect the priority of alternative items, different discount rates chosen for various objectives will do have their own adverse impacts on NPV calculation [30]. For example, according to Emhjellen and Alaouze, using the Weighted Average Cost of Capital (WACC) as the discount rate is willing to result in the overvaluation of the portfolio [30]. Meanwhile, using opportunity cost is limited by the projects and information we encounter. Finally, according to Costanza etal, discount rate, which is considered to be one basic conception, should not be constant but rather decrease with time [31]. Since the NPV conclusion is static to represent the point of time, this method leads to a calculation dilemma, whose result at present will also fail to accurately reflect future circumstances [31].

It's believed that the factor of discount rate has the greatest impact on the application of the NPV method. The most difficult obstacle is determining what reference data or accounting methods are used, how to make subsequent adjustments, and how to reduce the difficulty of calculation under rapidly changing market conditions. There is no agreed standard being proposed to select and adjust discount rates, and no strategies for decreasing calculating complexity have been suggested, thus more research is needed.

For the eight papers studied above, this part categorized them in the sheet below (TABLE I). In the categorization process, TABLE I included several aspects of Advantage, Disadvantage and their respective Author(s).

Table 1. Studies on the advantages and disadvantages of NPV

Advantage	Author(s)	Disadvantage	Author(s)
• The application of discounting as a basic notion.	Christian Gollier & Martin L.Weitzman	• Suffering from cash flow uncertainty	Hamid Beladi, Jie Deng& May Hu
• Demonstration of the project's liquidity and overall profitability.	Kevin Watson	• Unpredictable changes in NPV due to the hurdle rate	Thomas A.Weber
• Easy determination	Louise Gaille	• Different types of discount rates have adverse impacts on NPV calculation.	Magne Emhjellen &Chris M.Alaouze
• System risk and industry risk are taken into account.	Prachi M	• The discount rate is actually decreasing with time rather than stable.	Robert Costanza, Ida Kubiszewski, Natalie Stoeckl &TomKompas

2.2.3. Modified methods of NPV

The development of NPV has also been a constant process of refinement and revision. As a result, a number of more sophisticated NPV correction methods have been derived.

Cardwell has mentioned a method named decoupled net present value (DNPV) which separates the time value of money from the risk associated with projects [32]. DNPV method enables investors to price the risk related to the value of the product developed and/or the investment required to create the asset by combining heuristic (experience-based) procedures with an advanced probabilistic and stochastic techniques [32]. In other words, DNPV gets more reliable decision-making by separating the two separate variables which are time and risk, rather than directly equating the time value of money with risk.

The risk of an investment is inherently uncertain, but the NPV approach quantifies it directly as a specific fixed value, which may lead to biased decisions. According to Sanches, Pamplona, and Montevechi, fuzzy NPV avoids and deals with this problem very well by introducing fuzzy theory. Fuzzy NPV treats uncertain risk as a fuzzy variable rather than recognizing it as a specific value, thus creating a decision model based on fuzzy theory. Therefore, by taking into account the uncertainty of the risk variables, fuzzy NPV will lead to more accurate and comprehensive conclusions [33].

2.2.4. Advantages of IRR

For research on the optimal investment decisions, the IRR is a handy and useful method for calculating the economic rate of return on invested capital, which has been researched since Keynesian firstly put forward the concept ‘marginal efficiency of capital’ [34]. From then on, with the widespread use of IRR, many practitioners and decision-makers have become proficient in applying IRR and formed mature experience in operation.

The study by Duncan suggests that the advantages of IRR as an alternative can be seen easier in light of the NPV measure. Focused on the definition, the article illuminates that IRR is a strictly definable term, which can only be applied to evaluate the desirability of projects. Since it reflects the profitability of the project itself, it’s easy for the management to make the profit maximization, i.e., to choose the highest IRR which is greater than the hurdle rate. As Duncan says, they often compare IRR with the hurdle rate, indicating IRR is the upper limit on the interest rate that could be paid to repay the loan and still make a profit. The form of ratio also facilitates the comparison among the projects with different investment scales [35].

Besides, Babaei and Bamdad draw attention to the fact that there is no need to consider the financing problem when adopting IRR [36]. Unlike other evaluation indices, the calculation of IRR avoids the use of uncertain conditions of the interest rates, making it easier to get results. It is noticeable that the IRR method takes all the cash flows contained in different periods into account as well, according to Weber [37].

2.2.5. Disadvantages of IRR

Nevertheless, since many economists and engineers have taken the IRR method, they have found its pitfalls in the decision-making process, thus it is important to consider these special circumstances simultaneously when evaluating the desirability of investment projects. There have been many studies on the shortcomings of the IRR as follows.

First, as Cuthbert and Magni's paper shows, the use of IRR has strict preconditions that the relevant payment streams must be the type of flat and annuity ones [20]. When the net cash flows are not in pattern (i.e., unconventional cash flows), which is similar to the definition of 'fuzzy cash flow' promoted by Biacino and Simonelli, there will be more than one or no results of IRR, which has no economic meanings at this time [38].

A noticeable point is that an underlying assumption is implied in IRR. The paper by Weber reveals that the cash inflow generated by the project and the rate of return produced by reinvestment are the same as IRR, which might not be applied to all practical situations [37].

Moreover, as is described in a specific investment case by Jiang, IRR can’t show clearly that how many profits the company will gain by investing in this project because it is a non-dimensional rather than a scaled quantity, which is misleading [39]. To be more specific, if the capital cost is smaller than the crossover rate of return, the project with a low IRR has a higher net present value.

Unlike other articles, the study conducted by Xepapadeas looks from a broader angle rather than small details. It puts forward that when capital inputs are optimally adjusted in a competitive economy in long-run equilibrium if long-run equilibrium does not prevail, the IRR can be regarded only as an approximation of the true economic return that is generated by capital inputs [40].

For the seven papers studied above, the Advantage, Disadvantage and their respective Author(s) are categorized in the sheet below (TABLE II).

Table 2. Studies on the advantages and disadvantages of IRR

Advantage	Author(s)	Disadvantage	Author(s)
• Straightforward to use: the highest IRR which is greater than the hurdle rate	Duncan A. Mellichamp	• Strict precondition of payment stream: a flat, annuity	James R. Cuthbert&Carlo Alberto Magni's
• The form of ratio facilitates the comparison among projects.	Duncan A. Mellichamp	• The impractical assumption	Thomas A. Weber

• No need to consider the uncertain interest rate	Golnoosh Babaei, Shahrooz Bamdad,A	• No exact number of profits is gained.	Huanping Jiang
• All the cash flows contained in different periods are considered.	Thomas A. Weber	• The condition of long-run equilibrium is needed.	Xepapadeas, A.P.

2.2.6. Modified methods of IRR

In view of the existing drawbacks that IRR has above, many scholars have been dedicated to finding measures to modify the disadvantages of the traditional IRR. In fact, two methods have been recognized by academia, which is Modified Internal Rate of Return (MIRR) and Average Internal Rate of Return (AIRR).

According to Kierulff, under the circumstance of unconventional cash flows, adopting the MIRR method can not only avoid the situation of no or multiple solutions but also simplify the calculation process [41]. It also corrects the unreasonable assumption, replacing IRR with WACC as the reinvestment rate.

In addition, as Hazen and Magnithe pointed, the AIRR fixes many pitfalls related to the traditional IRR. When analyzing the projects with different levels of risk, AIRR forms a scale-efficiency decomposition of NPV, uniquely breaking down a risky NPV into a risk-sensitive project scale and extended AIRR. This shows the risky levels of investment projects, which is an intractable problem for IRR [42].

3. APPLICATION OF NPV AND IRR

3.1. Application of NPV

When NPV is greater than or equal to 0, the project is adopted. If NPV is less than 0, the item is discarded. And comparing multiple mutually exclusive items, we usually choose the item with the largest NPV. Professor Zhang of Nanhua University applies the NPV method to the economic analysis of uranium mining projects [43]. He finds that two problems need to be solved when using the NPV method for investment decision-making of uranium mining projects. One is to predict the future cash flow of the project, and the other is to estimate the discount rate. The final NPV value is about 660,000, which is far greater than zero, so it is worth investing. Finally, the fact that the uranium mine brings huge economic benefits proves the correctness of Zhang's analysis. It can be seen that the NPV method is perfect in theory, simple and direct. It can judge whether the investment can be made only by calculating the net present value of the project. Therefore, the NPV method has been widely used to make the investment decision of industrial projects.

Besides, we should also consider the application of additivity. Additivity means that if two items are independent of each other, their NPVs can be added. (Ross 2003 Corporate Finance) This feature has many valuable meanings which can make the NPV method convenient in application. For example, the relevant cost of a project is not considered in the calculation due to negligence and other reasons. In the calculation, the cost can be discounted and subtracted from the original NPV without adjusting other projects [44].

3.2. Application of modified NPV

Zhang and Xiao studied the problem of project value evaluation and portfolio selection under the assumption that the project investment capital and net cash flow are fuzzy variables [23]. They use FNPV to examine the profitability of an annuity investment project during its calculation period. According to the financial net cash flow of each year in the project calculation period, they get the appropriate value to select the comprehensive risk-return index of the optimal investment strategy.

At the same time, DNPV is also an effective modified NPV model. Dou and Pan analyzed the profitability of deep mineral resources development projects using DNPV method [25]. The researcher analyzed a manganese mining project located in Guizhou Province, China, selected several main risks affecting the expected income, and analyzed the feasibility of the project based on DNPV technology. Traditional economic evaluation methods are difficult to accurately identify and evaluate risks, but DNPV provides an effective tool to separate time value and risk cost, which is helpful to find the real value of the project.

3.3. Application of IRR

Based on the application of NPV, when IRR is greater than or equal to the discount rate of the project, the project is adopted. When IRR is less than the discount rate of the project, the project is abandoned. When comparing multiple equal items, we usually adopt the item with the largest IRR. Zou of Fudan University used the IRR method to analyze the investment of a road and bridge construction enterprise in the case of financial leasing and purchase of construction equipment [45]. After calculation, it turned out that when the yield was 10%, the IRR value was 13.25%,

indicating that the project is feasible. By observing the internal rate of return index, the financing company can not only see the income of the project but also observe the relationship between the project rate of return and capital cost after the change of capital cost. Therefore, the product attributes of financial leasing companies determine that it is practical to use indicators to make project income decisions.

We should also pay attention to the application of multiple unequal investment projects. Judging the advantages and disadvantages of an investment project depends on the situation. If the investment decision is judged only according to the investment efficiency of the project, the internal rate of return is the most suitable method for investment evaluation [46].

3.4. Application of modified IRR

In the paper of Kierulff, the MIRR method adopts different discount rates to calculate IRR, taking the cost of capital into account in the cash expenditure calculation. The average rate of return on reinvestment is considered in the calculation of income at the same time [41]. During the process of the decision-making with venture capital investments, the MIRR is applied to analyze whether the project is feasible through the comparison with the capital cost.

In practical applications, especially for projects with long-life cycles and uncertain fluctuation in the future markets, the MIRR is more associated with the market situation. The study by Johnston and his fellows takes the approach to evaluate the profitability of cultured pearl production [18]. However, the MIRR has deficiencies in relative independence and objectivity because of the dependence on the enterprise capital cost, which may cause disputes.

On the other hand, the AIRR method is the ratio of total profit to total investment, and it is also the capital weighted average of return on investment at the same time. This measure can be applied in both industrial projects and financial programs. In the study conducted by Cuthbert and Magni, the measure is taken to assess three PFI medical projects and compared with IRR to illustrate the danger in applying IRR as an index to evaluate the performance of financial projects [20].

3.5. Inconsistencies between NPV and IRR in practice

In practice, there may be inconsistencies between NPV and IRR. When using IRR rules and NPV rules in different situations, there may be different solutions. Firstly, multiple internal rates of return may occur when the cash flows are unconventional. For instance, there may be several IRRs when the cash flows change positively or negatively more than once [47]. The noticeable point is that multiple internal rates of return may produce a different result from the NPV calculation. When multiple IRRs appear, they should be considered in combination with NPV. A single IRR solution is not appropriate. Additionally, when two projects are mutually exclusive projects, inconsistencies between NPV and IRR solutions are also possible. Mutually exclusive projects are alternative projects that cannot be run simultaneously. When we make decisions, the NPV method is used to select the project with the highest NPV greater than 0 and the largest, and the IRR method is used to select the project with the highest IRR that is greater than the required rate of return. However, the two methods may give different results when the two projects are mutually exclusive. In such instances, when deciding between mutually exclusive projects, the decision-makers should choose the one with the highest positive net present value based on the appropriate cost of capital. The reason for this is that a company's goal is to maximize shareholder value, and the project with the highest NPV has the greatest impact on stock prices [48]. Managers should not only focus on the rate of return but more on the real return obtained. In this case, NPV is always the superior method. Because compared to the IRR rule, the NPV rule gives more logical and reliable solutions.

4. CONCLUSION

This paper reviews the advantages and disadvantages of NPV and IRR as well as their modified versions and applications based on forty-seven relevant papers. It is found that NPV and IRR methods may yield different decision results, and possible reasons of these findings are collated and discussed in detail in this paper. Additionally, the results of this paper can provide metrics for decision-makers who actually use NPV, IRR, or their modified versions to achieve optimal decisions in practice. The correct choice and application of NPV, IRR, as well as modified NPV and IRR will directly contribute to the company's ability to maximize profit. Therefore, this paper could provide good references for those who do research on investments in financial markets and company decision-making methods.

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