

Theoretical Analysis of Net Present Value

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Abstract. This paper reviews researches on net present value done by researchers in the past 25 years to summarize the research results and put forward limitations. Although the investment decision guided by net present value possesses a long history and investors use it widely in the current financial market, the author believes that it still has the value of being discussed and studied. After a comprehensive review, it is found that in the past 25 years, the research on net present value has focused on comparing its advantages and disadvantages with other investment decision-making schemes and how to apply the NPV approach to special industries, but less follow-up on the actual progress of subsequent investment projects. Despite the NPV approach is generally accepted as the gold standard for enterprises to make investment decisions, with the continuous development of international finance and economy, the success rate of using the NPV approach for investment might be extraordinarily different from that when the NPV approach was initially popularized. After the review, this paper finds that researchers lack practical consideration for the NPV approach. Therefore, the significance of this review is to attract researchers' attention to the above issue so as to make up for the gap in the later stage of research on the implementation of the NPV approach.

Keywords: Net Present Value, Review, IRR, Real Option.

1. Introduction

1.1 Research Background

The NPV approach takes the time value of money as the main discounted cash flow reference index, comparing it with the project cost to obtain the optimal investment decision. It takes the time value into consideration, which reflects the revenue potential of the project, and is simple to understand and calculate. Therefore, the NPV approach is widely used internationally and is considered to be the first criterion for making investment decisions. The specific time when the NPV approach is widely regarded as the investment decision standard has not been determined in the academic circle, but the time when it is used as an essential indicator of feasibility study has been relatively determined. In 1958, the world bank and the United Nations Industrial Development Organization requested that financial analysis and economic analysis be used simultaneously in evaluating loan projects so that the standard of the feasibility study could be popularized worldwide. Therefore, the NPV approach is widely spread as an analysis method. However, whether it can genuinely reflect the profitability of investment projects has been controversial in recent years.

1.2 Research Significance

Although the NPV approach has irreplaceable advantages in investment decision-making, it still has apparent shortcomings and limitations. Therefore, researchers have been committed to better understanding the NPV approach to optimize investment decisions. Some studies have pointed out that if investors use the net present value approach as the primary rule may cause some inefficient capital allocation results. This standard is vulnerable to other factors, resulting in investment decision-making mistakes [1]. Although future generations have constantly improved the NPV approach to make more accurate investment decisions, such as the risk NPV approach developed by integrated the weighted average cost of capital method with the dual risk return method. It can provide more accurate decisions for the risk assessment and investment of privately financed infrastructure projects [2]. However, with the integration of financial markets and social environment or political factors, whether the NPV approach can still perform well as when it was first popularized is a topic worthy of consideration.

1.3 Paper Organization

This paper will summarize the research on net present value in the past twenty-five years. The author selects representative twenty works of literature from the past twenty-five years to summarize and review the research results. The review's focus will be divided into three parts: the research of net present value and its derivatives, the similarities and differences of net present value and other investment decisions, and application of net present value in multiple directions. The author will review and summarize the main fields and characteristics of the research on net present value, find out the existing research's limitations on net present value, and predict the future development direction.

2. Literature Review

2.1 Research on Net Present Value Theory and Derivatives

When evaluating an investment project with uncertainty, the economic reliability of financial efficiency indicators depends on its strong consistency of the net present value. The indicators that affect investment decisions can use net present value as a measure, which shows the benchmarking role of net present value in evaluating various investment indicators [3,4]. However, using NPV as the investment standard may lead to inefficient capital budgeting results. This standard is dominated by other capital budgeting standards, such as IRR and profitability index [1]. Meanwhile, the NPV approach is based on the judgment of cash flow so it will ignore the value of flexibility in an uncertain environment [5]. Therefore, many researchers have improved the NPV approach and thus derived the high-order NPV approach based on the NPV. The strategic NPV approach proposed by Smith and Trigeorgis combines real option method with game theory and NPV approach. At the same time, Lin studies the role of the discount factor and growth factor under the combination of real options and the maximum NPV approach to improve investment decision-making accuracy in an uncertain environment [6,7]. Meanwhile, the NPV risk modelling method developed by Hopkinson using NPV can also predict the impact of project-specific risks on investment decisions [8]. Espinoza and Morris proposed a decoupling NPV approach that decouples the time value of funds from project risks to solve the limitations of the NPV approach in the typical long-term investment of large-scale basic projects [9].

2.2 Research on Comparison of Net Present Value with Other Investment Decision Making Methods

Researchers usually compare various investment decision-making methods to expect the most accurate investment decision. NPV approach is widely regarded as the golden rule. Nevertheless, another method, the IRR method, is also considered a better criterion to guide investment decisions. Although the discount rate is also used as an essential parameter, the two will still lead to contradictory results in investment decisions. Some studies believe that when investing in no mutually exclusive projects or projects with reinvestment in the middle period, the NPV approach as a static evaluation index is inferior to the IRR method [10]. Moreover, the two belong to different investment feasibility indicators. That is, the net present value belongs to economic indicators, and the IRR belongs to financial indicators. However, they have considerable reference value for the guidance of investment decision-making [11]. Therefore, the comparison of the advantages and disadvantages of the two has been endless for many years. However, some studies have found that a new net present value equation can be obtained by reorganizing the N solutions corresponding to the polynomial of the monetary equation; this shows the consistency between the IRR and the net present value to a certain extent [12]. Similarly, Bosch, Montllor Serrats, and Tarrazon proved the compatibility between net present value and IRR by developing a method to obtain normalized interest rates [13]. Based on the same tendency shown by the two to a certain extent, Weber introduced the selective IRR method to make the results entirely consistent with the NPV approach in many cases, and there

are no known shortcomings of the IRR method [14]. This attempt is an example of improving other investment standards based on the NPV approach. In addition to enhancing the research of a single method, some researchers have also combined the IRR and net present value to propose a robust decision-making method to optimize the shortcomings of the two to a certain extent [15]. Similarly, Arjunan uses the ending balance in the capital amortization schedule to replace the discounted cash flow and improves the definition of net present value and IRR [16]. In addition to the IRR, indicators such as repayment time and interest rate index can also be used to guide investment decisions. Some studies have found that within a specific confidence interval, there is a characteristic relationship of normal distribution between indicators such as net present value, IRR, repayment time and interest rate index, and the discounted cash flow that the project may generate in an uncertain environment. This means that investors can estimate the lower limit probability of the above investment decision in the face of an uncertain environment by establishing a confidence interval [17]. It is worth mentioning that, based on the disadvantage of the NPV approach facing uncertain environment, the real option method has been more widely used in recent years. Therefore, some researchers have made a comparative study between the real option method and the NPV approach. Although these two are based on the same assumptions to some extent, such as the perfect market assumption compared with the NPV approach, the real option method is more specific for measuring project liquidity [18]. Nevertheless, as a widely recognized investment decision-making guideline, the NPV approach is still irreplaceable. Some studies have shown that the advantage of the real option method for uncertainty is not as good as expected and may bring more practical problems [19].

2.3 Research on Application of Net Present Value in Multiple Directions

The research on applying the NPV approach and its derivatives to specific projects is also one of the topics discussed by researchers in the past 25 years. Researchers often have more realistic considerations when studying this problem, that is, in addition to the net present value, the actual project will involve more variable factors, which may affect the accuracy of the estimated net present value. For example, Goldenberg, LiBai, Moldovan and Muller have studied the impact of negative news in social networks on the company's net present value [20]. Some researchers also use NPV as the main reference standard to compare the impact of different factors on discounted cash flow. Kumar, Sharma and Tewari made a cost analysis of coal-fired power plants using NPV [21]. Vučina, Lozina and Vlak solved the problem of multi-objective decision-making in design by establishing a new functional model using net present value and IRR [22].

3. Conclusion

3.1 Main Findings

By reviewing the literature on NPV research in the past twenty-five years, the author of this paper has a deeper understanding of the net present value research field. In the research process, this paper found that although the NPV approach has been widely accepted and recognized, researchers have not given up further research and discussion on the NPV approach for many years. This situation makes the NPV approach has been continuously improved to adapt to the increasingly drastic changes in economic and financial forms. In this context, this paper divides the research on the NPV approach into two main parts, i.e., theoretical research and comparative research for literature review. Specific findings can be shown as follows:

On the one hand, in the past twenty-five years, researchers' discussions on the theory of NPV approach have focused on whether it can accurately express the discounted cash flow in an uncertain environment, from which many improved methods based on net present value have been derived. It still takes the NPV approach as the main framework. However, compared with the traditional NPV approach, the derivative method often improves on one of the weaknesses of the NPV approach. For example, the combination of real options and NPV approach solves the shortcoming of the traditional NPV approach in the face of an uncertain environment. In contrast, the decoupling NPV approach

solves the limitations of the NPV approach in front of uncertain time risk. On the other hand, researchers have different opinions on whether the NPV approach is the gold standard for making investment decisions. Therefore, the comparative research on the NPV approach and other investment decisions in the past twenty-five years accounts for the vast majority of the research on the net present value. Because the IRR is also based on the time value of money, researchers often use it as a comparative factor of the NPV approach. Nevertheless, researchers did not simply compare the different features of the two methods but obtained the potential connection between NPV and IRR by comparing the consistency of the two methods in some cases and thus improved the two methods at the same time. It is worth mentioning that although some particular investment decision-making guidelines (such as the payback time and profit index) are rarely used in practical application, some researchers still have a comparative study with the NPV approach. In addition, some researchers have compared the NPV approach with the real option method. Although the real option method has more significant advantages in the face of uncertainty, it may also bring more practical problems. Therefore, the author believes that the universality of the NPV approach is still higher than all other investment decision-making guidelines. Based on the wide application of the NPV approach, many researchers have also studied its application in various fields. Researchers have added more practical considerations to this issue, that is, the impact of real environmental factors on NPV. These studies make the net present value theory have more practical significance and practicality.

3.2 Further Studies

The existing theoretical research focuses on the limitations of the NPV approach in the face of uncertain cash flow, that is, whether the NPV approach should be used as the leading standard of investment decision-making in an uncertain environment. The derived investment method based on net present value is used in actual projects as a measurement standard before investment decisions. Similarly, the comparative study on the NPV approach also focuses on the advantages and disadvantages of various methods before making investment decisions. The comparative study takes less consideration of other investment methods, i.e., discounted return time. Although it has more limitations than the IRR, the author believes its role may be greater than the net present value and the IRR in some specific cases. In addition, the research on applying the NPV approach also focuses on improving the NPV approach so that different enterprises can make the optimal investment decision according to it. Based on the above research findings, the author of this paper believes that the existing research on net present value focuses on the performance of investment projects before investment decisions are made, and there is less research on the implementation of investment projects after the application of NPV approach. Due to the change in the environment in which the investment project is located, there may be a significant difference between the prediction of the project cash flow and the level of accuracy of the NPV approach and its derivative methods and the initial investment decision-making. Researchers can turn their research perspective to the improved methods that cannot achieve the expected return after using the NPV approach or study the factors that affect the accuracy of the NPV approach to correct the error of the NPV approach in the process of project implementation and make up for the blank of later research on NPV approach.

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