Application Analysis of Main Project Evaluation Tools

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Abstract. With the development of financial economy, the toolbox of project appraisal has become more and more abundant, and many decision makers do not know how to choose the most appropriate tool when they are faced with a large number of project appraisal tools when evaluating a project. In the project evaluation toolbox, Net Present Value (NPV), Internal Rate of Return (IRR), Modified Internal Rate of Return (MIRR), and Economic Value Added (EVA) are the four most widely used project appraisal tools nowadays, which are required by almost all decision makers in project appraisal. This paper provides an overview of the concepts, forms, limitations, and applications of NPV, IRR, MIRR, and EVA with the aim of providing the audience with a general understanding of these four program evaluation tools. Based on this, the paper further discusses a comparison of the application of these four project appraisal tools in different situations, showing the differences in their applicability in different situations. The purpose of this paper is to provide decision makers with some basis for the selection of appraisal tools.

Keywords: Comparison; Project appraisal tools; NPV; IRR; EVA.

1. Introduction

The selection of project appraisal tools has become a major concern for decision makers. With the continuous development of financial economy and the increase of research on project appraisal methods, the toolbox of project appraisal is getting richer and richer, and with the project appraisal methods such as DCF, NPV, IRR, MIRR and so on gradually proposed, the decision maker's appraisal of the project has become more comprehensive. However, faced with so many project evaluation tools, it is often difficult for decision makers to judge which tool to use to evaluate a project.

Agnes' study pointed out that decision makers in small firms should prefer IRR due to the convenience of IRR and the comprehensibility of measuring it as a ratio, but the fact is that decision makers in large firms prefer IRR over decision makers in small firms [1]. Siziba's study in Dubai shows that decision makers in Dubai use ROI mainly as an initial evaluation technique and NPV, IRR for more sophisticated level of analysis [2]. Batra's study shows that MIRR is considered superior to IRR according to academic theories but is rarely used by decision makers in project appraisal, while relatively mature appraisal tools such as EVA, real options method are also favored by only a small number of companies [3]. It can be seen that there are problems and differences in the use of project appraisal tools among different decision makers, who often cannot come to a unified conclusion about which project appraisal tool to use in which situation.

Based on the research on project appraisal tools, this study chooses four mainstream project appraisal tools, namely, NPV, IRR, MIRR, and EVA, as the object of study, and tries to find out the application of these four project appraisal methods in different situations. This study firstly analyzes the methods, advantages and disadvantages, limitations and applications of these four project evaluation tools. Secondly, the four project appraisal methods are compared and analyzed in an attempt to find out their applicability in different situations. This study aims to provide decision makers with a basis for choosing assessment tools for project evaluation.

2. Mainstream Project Evaluation Toos and Their Applications

2.1. Introduction and Applications of NPV

2.1.1. Background and usage of NPV

The concept of NPV was first introduced by Fisher in his book: the Interest rates. According to his description of NPV in the book: The difference between the present value of current and future cash inflows and the present value of current and future cash outflows is known as NPV. [4]. Based on the concept of NPV, NPV can be calculated by discounting the present value of future and present cash flows, the formula of NPV is:

$$\text{NPV} = \Sigma_{t=0}^{T} \frac{C_t}{(1+i)^t} \quad (1)$$

In formula (1), C_t represents the Net cash flow in year t, i represents the Discount rate, and T represents the project period.

The use of NPV should follow some principles, when using NPV to evaluate projects, decision maker should accept projects with NPV greater than 0 and discard projects with NPV less than 0. In addition, when evaluating multiple projects, decision maker always choose the project with the largest NPV to invest in.

2.1.2. Advantages and Disadvantages of NPV

(1) Advantages of NPV

First, NPV provides a method of estimating the value of projects, it allows shareholders to estimate the value of each project and rank them to find the optimal project, and in other words, it provides a way to maximize shareholder wealth.

Second, NPV takes into account the time value factor. The NPV rule assumes that today's money is more valuable than future money because people can use today's money to make investments and obtain returns in the future. In addition, the uncertainty of the future is plays a significant role in whether the assumption is valid. , because the uncertainty of the future means that future money bears more risk.

Third, NPV takes into account the opportunity cost factor where people use today's money to invest in a project, which means that people give up using that portion of the money to make other investments and make a profit.

(2) Disadvantages of NPV

First, NPV has the characteristic of uncertainty, the uncertainty of NPV mainly comes from two factors: future cash flow and discount rate. Usually, people assume that the future cash flows are known and the discount rate is fixed for each year when people do the NPV calculation. In reality, it is difficult to accurately predict what the future cash flows will be, and the discount rate is often not fixed for each year in the future, these deviations lead to uncertainty in NPV.

Second, NPV does not express the incremental increase in wealth. According to the conventional NPV formula, a project's NPV is just the total of its net cash flow present value. The numerical numbers offered by standard NPV calculations might not adequately reflect a project's incremental contribution to firm value when the future is unknown. Decisions based on those calculations might not maximize business value as a result [5].

Third, the calculation of NPV is cumbersome; it requires us to know the cash flows and the annual discount rate in the future, which is not easy to obtain, and there are many simpler ways to evaluate projects than NPV, such as IRR.

2.1.3. Applications of NPV

NPV is the most widely used project appraisal method, which has the advantages of simple calculation method and easy to use, and NPV has a well-developed theory and is recognized by most decision makers in practice. In addition to bond investment and so on, NPV is also widely used in coal mining, the purchase of medical equipment and so on, the application of NPV exists in a variety

of industries and in a variety of fields. Zhang affirms the scientific and practicality of the NPV method in the mining industry [6]. Mao affirms the application of NPV method in real estate investment through empirical analysis [7]. Liu listed the investment guidelines of NPV in assessing real estate projects [8]. Despite some drawbacks of NPV method, it is undeniable that he is still the most commonly used valuation tool.

2.2. Introduction and Applications of IRR

2.2.1. Background and usage of IRR

IRR is the discount rate at which the total present value of cash inflows equal to the total present value of cash outflows. In other words, the IRR is the rate at which the NPV of the project is zero [9]. The formula of IRR is:

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

In formula (2), C_t represents the Net cash flow in year t, C_0 represents the Net cash flow in year t, and T represents the project period.

The use of IRR should follow these principles: when using IRR to evaluate projects, decision maker should accept IRR above the hurdle rate and discard IRR below the hurdle rate. In addition, the higher the IRR of a project, the higher the return on the project. When evaluating multiple projects, decision maker not only choose the project with the highest IRR to invest in, but also determine whether the IRR is above the hurdle rate.

2.2.2. Advantages and disadvantages of IRR

(1) Advantages of IRR

IRR is very easy to calculate, when doing the calculation of IRR, decision maker only need to know the future cash flow of the project. Therefore, IRR is easier compared to other project appraisal methods.

(2) Disadvantages of IRR

First, IRR ignores the size of the project, IRR assumes that the projects are all of the same size. Therefore, the IRR method can only be used in projects of the same size and is not valid in projects of different sizes.

Second, IRR implicitly assumes that the return on reinvestment is the same as IRR. In practice, however, this assumption may not hold, as revealed in Weber's paper [10].

Third, when evaluating a project, IRR may have many solutions or no solutions. If the cash flow sign in the project changes twice or more, then the IRR of the project is not unique, and then it is difficult to evaluate the project based on the IRR.

Fourth, IRR is not applicable to mutually exclusive projects. IRR does not hold when comparing and choosing between two mutually exclusive projects, which can easily lead to poor judgment if an investor chooses one project simply because it has a higher IRR.

2.2.3. Applications of IRR

As a simple and intuitive project evaluation tool, IRR is widely used in various fields, and is known as one of the two most widely used project evaluation tools together with NPV. IRR has good applicability. Qiao points out that IRR is presently a crucial analytical tool for the evaluation of the economic feasibility of engineering projects [11]. Liu affirmed the importance of IRR in the evaluation of real estate projects, and pointed out that IRR can provide a scientific reference basis for the selection of real estate investment projects [12]. In addition, IRR can be used in many fields, such as medicine, mining, education and so on.

2.3. Introduction and Applications of MIRR

2.3.1. Background and usage of MIRR

First discovered by Baldwin in the 18th century, MIRR is an important method of project evaluation that addresses many of the problems in IRR, such as conflicts with NPV results, multiple solutions. [13]. Modified IRR is a more reasonable discount rate than IRR, The formula of MIRR is:

$$\Sigma_{t=0}^{T} \frac{COF_t}{(1+marr)^t} = \frac{\Sigma_{t=0}^{T} CIF_t(1+marr)^{T-t}}{(1+MIRR)^T} \quad (3)$$

In formula (3), COF_t represents the Cash outflow at time t, Marr represents the Minimum return on capital, T represents the project period, $and\ CIF_t$ represents the Cash inflow at time t

When evaluating projects using MIRR, decision maker use MIRR to rank the projects in order; the larger the MIRR, the higher the return on the project, and decision maker always choose the project with the largest MIRR.

2.3.2. Advantages and disadvantages of MIRR

(1) Advantages of MIRR

First, The MIRR method does not suffer from multiple or no solutions. The MIRR method can be solved directly and there exists a unique solution and there are no multiple or no solutions as in the case of IRR.

Second, MIRR's assumptions about reinvestment are more reasonable. MIRR assumes that the reinvestment rate is equal to the MIRR. In the time axis MIRR assumes that the net cash flow in each period is invested at the rate of return of the MARR. The MARR considers the cost of capital, the risk of the investment, and other factors. Compared to IRR, MIRR is more reasonable and realistic in its assumptions about the rate of investment [14].

(2) Disadvantages of MIRR

First, Complexity of calculations and the need to assume a suitable MARR. For non-financial people, the calculation of MIRR may be difficult because it requires not only mathematical calculations but also the assumption of an appropriate MARR. In addition, the assumption of MARR is subject to subjective factors and when the assumption of MARR is different, the value of MIRR will also change. Therefore, to calculate the correct MIRR, not only correct mathematical calculations but also the assumption of a suitable MARR are required.

Second, MIRR does not apply to the evaluation of mutually exclusive projects. MIRR is a rate-of-return method, the MIRR approach is inaccurate when comparing options that are mutually exclusive. Only when evaluating the acceptability of an alternative is MIRR applied [14].

2.3.3. Applications of MIRR

As a project appraisal tool created from IRR, MIRR overcomes the limitations of IRR and complements the project appraisal toolbox. MIRR can be used in a variety of areas, especially where IRR is not feasible. MIRR has been used in a variety of areas such as coal mining, real estate investment, etc. In addition to this, MIRR can also be useful for watershed studies, as Satyasai's 2009 study reports noted that MIRR can solve the problem of differences in scale and time span [15]. Although the MIRR method is not as commonly used as NPV, IRR, it is undeniably a good tool for project evaluation.

2.4. Introduction and Applications of EVA

2.4.1. Background and usage of EVA

Stewart introduced the concept of EVA, a measure of corporate financial success, in the 1980s [16]. It measures the excess return that an investment provides over the rate of return on the market. Simply put, EVA measures profitability after capital expenditure [17]. The formula of EVA is:

$$EVA = NOPAT - WACC*TC \quad (4)$$

In formula (4), NOPAT represents the After-tax net operating profits, WACC represents the weighted average cost of capital, and TC represents Total assets

Decision makes need to follow these principles when using EVA: If the EVA is positive, the company generates wealth for its shareholders. Negative EVA signifies the destruction in shareholder wealth [18]. When evaluating projects using EVA, decision maker should select projects with positive EVA and the larger the project EVA the better the project, decision maker also should select the project with the largest EVA.

2.4.2. Advantages and disadvantages of EVA

(1) Advantages of EVA

First, the EVA method shows the allocation of cash to specific projects. Traditional discounted cash flows do not provide any process to allocate the investment funds to each product. What is calculated from the cash flow is only the cash generated by the investment fund as a whole and cannot be specific to each product, which can result in an inaccurate assessment. EVA, however, allocates cash specifically to a particular product to track its sole contribution to the company's wealth [18].

Second, the EVA method takes into account the cost of equity financing. EVA considers all costs of capital. In contrast, traditional business valuation metrics consider only the most obvious cost of capital, ignoring the cost of equity financing [18]. And the cost of equity is a key financing consideration for most growing companies, ignoring the cost of equity can lead to inaccurate valuations.

(2) Disadvantages of EVA

First, there are limitations on the scope of use of the EVA method. EVA is generally used for ordinary enterprises, but not for highly cyclical companies and newly established companies. The profit fluctuation of the highly cyclical company is too big, which may cause the deviation of EVA value; the newly established company's profit fluctuation is big in the initial period, and it is difficult to determine the investment projects by this method, which is not suitable for using EVA method for the time being [19].

Second, the calculation of EVA is highly dependent on the transparency of the company's internal information. The calculation of EVA requires detailed information about the company's internal information, such as the company's research and development costs for each project, investments, inventories, etc. It is difficult to obtain the information needed for the calculation of EVA when evaluating a company with low transparency of information [20].

Third, EVA cannot assess the future operation of the project. The calculation of EVA value does not include non-financial information, only financial information. And the financial information are historical data that illustrate the lingering effects of the business's previous operations, and can only reflect information about the results, not about the steps taken to arrive at the results. Therefore, people cannot use these data to make predictions for the future [21].

(3) Applications of EVA

Since the idea of applying EVA to valuation was introduced, EVA has been widely used in the appraisal of investment projects and has been widely successful. Costco, COCA-COLA, TU and many other well-known companies' shareholders use EVA as a tool to evaluate and management their companies. EVA also used by investment firms like Global Asset Management and Oppenheimer Capital in the process of choosing stocks, constructing portfolios, and managing risk. Additionally, related research in the Journal of Portfolio Management also demonstrates the significant contribution of EVA to the financial community [22]. Seyed confirms the validity of EVA valuation and suggests that EVA should be used more often in the purchase and sale of oil stocks [22]. Zhang concludes that "EVA is a reliable valuation method that can truly reflect the earnings and value of a real estate company when it is applied to the valuation of a real estate company [23]. The use of EVA as an assessment tool has good applicability in most industries.

3. Comparison of the Applications of NPV, IRR, MIRR, and EVA Tools in Different Situations

As economics continues to evolve, the toolbox for project appraisal has become richer and richer. However, in the face of a wide range of project appraisal methods, a significant problem is highlighted, that is, it is difficult for people to choose an optimal method to appraise a project among the many appraisal methods. In this section, this paper will compare and analyze different project appraisal methods to find out their applicability to different investment projects, so as to provide a basis for people to find out the optimal choice among the many methods for project appraisal. Among the many project appraisal methods, NPV and IRR have been the two most widely used methods, which are favored by decision makers and applied to all kinds of investment projects. Although they can be used to appraise most of the investment projects, they have some limitations in the face of specific investment projects.

The paper first discuss the application of NPV, the time value of money and the consideration of all cash inflows to the project are the main reasons why the NPV method is widely used [24]. In project appraisal, NPV is applicable in most cases, especially when appropriate discount rates and cash flow data are available. In addition to this, because of its additivity, the NPV method plays a great role in evaluating mutually exclusive projects. However, decision maker have to pay attention to the following situations: firstly, decision maker should be cautious in using the NPV method when investing in large-scale projects because the NPV method only measures the return of the project but not the rate of return of the project, and therefore the NPV method tends to give preference to large-scale and low-production investment projects when evaluating the projects. Therefore, the NPV method is not suitable for evaluating large-scale and low-yield projects, such as those in the traditional processing and manufacturing industries. Secondly, the NPV method is also not suitable for projects with a high degree of uncertainty. For example, projects concerning unconventional energy sources, in which the uncertainty is greater and the investment risk is higher, the NPV method does not take into account the value of the option brought by the uncertainty in the appraisal, which will also result in an inaccurate appraisal [25]. In addition, NPV method is not applicable in some projects where cash flow is difficult to estimate, such as social welfare projects, road projects, etc. The cash flow (income) of these projects is difficult to estimate, so decision maker can't use NPV method for project appraisal. Finally, NPV is also not applicable to the comparison of independent projects, because project NPV is an absolute value indicator, and when evaluating multiple independent projects, if the original investment amounts of each programme are not equal, it will lead to inaccurate evaluation [26].

As an equally widely used project appraisal method, the IRR method is widely used mainly due to its ease of use and ease of computation, and attractiveness as a percentage measure [24]. Unlike NPV, the IRR method shows the profitability of the project rather than the profitability of the project. Therefore, the IRR method is well suited for evaluating projects where the main basis for decision-making is the rate of return, such as finance leasing projects, where the decision-making is closely related to the rate of return [27]. In addition, due to the simplicity of the calculation and application of the IRR method, it is also particularly suitable for projects in complex environments and involving many industries, in which the use of the IRR method can simplify the problem. However, the IRR method is not applicable in the following cases: firstly, because the IRR method uses percentage as a measure, it cannot reflect the profitability of the project, but only the profitability of the project. Therefore, when comparing projects of different sizes, decision maker cannot use the IRR method for evaluation. In addition, the IRR method is not suitable for evaluating projects with too much fluctuating cash flows, such as new company projects, high-tech projects, pharmaceutical projects, etc. This is because once the sign of a project's cash flow changes, multiple IRRs are generated, making it difficult to evaluate the project using the IRR method. Finally, the IRR method is not applicable to the evaluation of mutually exclusive projects, such as projects related to engineering design, which generally involve the comparison of two or more mutually exclusive scenarios of

conventional projects, and the IRR method is prone to errors when it comes to the evaluation of mutually exclusive projects [28].

As an improvement of the IRR method, the MIRR method is more accurate and has a wider scope of application than the IRR method. Compared to the IRR method, the MIRR method corrects the problem that multiple solutions may be generated during the assessment process. As a result, the MIRR method can be applied to projects where the sign of the cash flow changes. In addition to this, the MIRR method distinguishes the rate of return from the reinvestment rate, which is more realistic in the project appraisal process, and therefore more accurate in the appraisal than the IRR method. However, the MIRR method still cannot be applied to the appraisal of projects of different sizes and mutually exclusive projects because it is still used as a percentage measure, just like IRR.

In theory the EVA and NPV methods are equivalent, they get the same results, but the two methods have different interpretations of the results. EVA is a time period concept and NPV is a point in time concept, so the EVA method shows the capacity of a business to generate profit [29]. Since EVA gauges a company's capacity to generate profit, it is more suitable than NPV for the evaluation of high-tech or emerging companies, which generally have a high ability to create economic value, and decision maker need to take this into account when making investment decisions. In addition, in project appraisal, decision makers often combine the EVA method with other project appraisal methods to comprehensively evaluate a project. Compared with the NPV method, the EVA method has a finer division of cash, and using the EVA method can provide a more direct and clearer understanding of the investment project. In some projects with large capital investment, such as coal mining projects, road construction projects, etc., decision maker can use the EVA method to understand the use of funds and make a comprehensive assessment of the project.

4. Conclusion

This paper summarizes the previous studies and provides an overview of the specific forms, limitations, and applications of the mainstream project appraisal methods, and based on this information, further compares the application of the major project appraisal methods in different situations in an attempt to find out the most applicable project appraisal method in a given situation. This paper summarizes the application of the four mainstream project appraisal methods and draws the following conclusions:

The NPV method is applicable to the appraisal of most projects, especially the appraisal of mutually exclusive projects, but decision maker must be conscious of the fact that the appraisal of the NPV method may be inaccurate in the appraisal of projects of larger scale, projects with greater uncertainty, projects with difficult to estimate cash flow, and the appraisal of stand-alone projects. Compared with the NPV method, the IRR method has a smaller scope of application, but it is characterised by simplicity of calculation and use, which makes it more suitable for evaluating projects based on the rate of return, as well as projects in complex environments. However, the IRR method is not applicable to projects of different sizes, projects with fluctuating cash flows, and mutually exclusive projects. The MIRR method is an improvement of the IRR method, which has a wider scope of application and is a good valuation tool, but it is still not applicable to projects of different sizes and mutually exclusive projects. The application of the EVA method is similar to that of the NPV method in project appraisal, but it is more suitable for high-tech or emerging companies, which have higher ability to create economic value, as well as for projects with large capital investment.

The main contribution of this paper is to analyze the applicability of NPV, IRR, MIRR and EVA in different situations, which helps decision makers to choose the most suitable assessment tool for the project when faced with a large number of project appraisal tools and provides a reference for other researchers to assess specific projects.

Finally, the shortcoming of this paper is that it does not analyze all the project appraisal methods that currently exist, but only selects the ones that are more widely used, and future research can

expand the applicability of the mainstream project appraisal methods in specific situations to all project appraisal methods in specific situations.

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