Comparison of NPV and IRR Rule Based on an Empirical Examination

Han Lin[1, *, †], Manni Zhang[2, †], Carl Wang[3, †]

guanghur.ren@gecacademy.cn[1], annie_zmn@hotmail.com[2], carlwang711@gmail.com[3]

Guangzhou Foreign Language School, 511455, Guangzhou, China[1]
Hangzhou Foreign Languages School Cambridge A-Level Centre, 310023, Hangzhou, China[2]
Centaur, Basis International School Park Lane Harbour, 516082, Huizhou, China[3]
[†]These authors contributed equally

Abstract—This research is conducted to compare differences between internal rate of return and net present value rules when given different conditions. With equations like NPV=C0+Cashflow1/(1+r)+Cashflow2/$(1+r)^2$+....Cashflow T/$(1+r)^t$, this essay compared different performances of two rules when different conditions are given. Our interest in this field originated from a specific project of an industrial company which led us to conflicts of two rules at a management meeting. To figure out the advantages and problems of each rule under different circumstances, this essay analysed the characteristics of both rules when they are subject to the effects of external factors and internal factors. Furthermore, some crucial information about some fund-raising projects of an industrial company located in Guangzhou was collected and used to analyse the performance of IRR and NPV rules. Overall, conclusion of this essay is two rules should always be applied at the same time. Regardless of possible conflicts, both reflect returns of projects, and two rules are related. Despite possible differences in percentage changes in values of NPV and IRR caused by external and internal factors, both reflect a prediction of returns of projects. For managers, it's better to compare two rules as changes in cash flows are unpredictable, and such changes are always subject to specific projects.

Keywords-NPV, IRR, Manager, Project, Cash flows

1. INTRODUCTION

Both NPV and IRR are essential concepts in finance. NPV, also known as Net present worth, represents the present value of a cash flow depending on the interval of time between now and the cash flow. Stefan Reichelstein [1] mentioned that managers should accept projects with a positive NPV, indicating that NPV always acts as a decision-making tool for managers. Previous researchers like AlistairMilne [2] and Willem [3] saw it as a tool for managers' decision-making. Despite some conflicts with the ORR definition mentioned by Miroslaw [4], the NPV indicator is still accepted by most managers. From the perspective of internal rate of

ICEMME 2022, November 18-20, Nanjing, People's Republic of China

DOI 10.4108/eai.18-11-2022.2327118

return (IRR), the rate of return sets the net present value of all cash flows (both positive and negative) from the investment equal to zero. According to the survey and derivation of Nalinaksha [5], most managers prefer IRR and view IRR as a tool to evaluate the riskiness of the capital budgeting proposal. However, as mentioned by Moshe [6] and Phalippou [7], limitations of IRR still exist, and its improper to only use IRR to measure project performance.

Under the topic of conflicts between NPV and IRR, researchers like Sayan [8] mentioned that different timing of cash flows and severity of discount factors of projects are likely to lead to contracting results as depicted by Net Present Value and Internal rate of return. Unlike previous research, we would discuss differences between IRR and NPV rules when they are subject to external factors and internal conditions.

By comparison, NPV may be more generous, while IRR may be subject to several factors like changing signs of cash flows. Previous essays like "A Resolution to the NPV–IRR Debate?" by Osborne [9] have compared the IRR rule with NPV in the aspect of concepts. In this thesis, both NPV and IRR rules will be tested under different conditions and comparisons between the two rules would be demonstrated by derivation. Compared with previous research, our essay emphasizes changes in cash flows caused by external factors and internal factors, and we would provide a sample to prove our derivation.

In this article, we apply the calculation of both NPV and IRR to our simulation and actual data about an industrial company. Then, by putting values of cash flows and NPV and IRR into tables, we can compare differences between two rules like different percentage changes caused by external and internal factors. Our research showed that decision-making should be based on actual situations, and both rules should be applied at the same time. Possible changes brought about by both external and internal factors should be considered, and it is wrong to rely heavily on one rule or ignore actual situations.

In the first main part of the paper, we explain the main factors influencing NPV and IRR. To better illustrate the factor and enhance the comparison process, two examples with data and tables are used to support it. Then in the second main part, we did an actual analysis with the corporation of a Guangzhou company by calculating NPC and IRR then comparing figures. At the end of the paper, we drew conclusions based on what we had analysed and examined, and we pointed out the drawbacks and possible improvements as well.

2. COMPARISON FOR IRR AND NPV

2.1 External Factor Impact

To begin with, the effects of projects should be considered carefully. As mentioned by Krzysztof Jackowicz et al. [10], some methods in determining cash flows may lead to the inaccurate value of cash flows. From the perspective of external effects or combined effects with other projects, it is worthwhile to take such effects into account.

Assuming that there's a tollbooth project, and it might be supposed to produce a small amount of cash flows due to relatively low local population density. In the long run, when urban plans of perimeter zones have been materialized and the number of locals rises, long-term cash flows may rise. Thus, tollbooth may underestimate cash flows at the beginning, and NPV may be

underestimated. Even better, if a tollbooth is included in an incremental project which contains a bridge-building project, cash flows produced by tollbooth may increase more sharply in the future. Compared with the NPV rule, the percentage change of IRR would be smaller.

Here's an example to prove the previous derivation. (presented in Table 1) In that example, we assume that cash flows of years 4, 5, 6 are affected by external factors. Then, we can compare the proposed cash flows of project A and the actual cash flows of project A (Represented by project A'). Despite the increase of both values of NPV and IRR, the proportion increase of IRR is relatively lower than NPV. This proves that the evaluation of IRR is more valid than NPV when there's a long-term external factor that affects the project's cash flows.

According to the research of Robison, L.J, et al. [11], Inconsistent IRR and NPV investment rankings have been attributed to differences in implied reinvestment rates, initial investment sizes, and terms. In this case, inconsistent changes in IRR and NPV investment rankings could result from initial investments sizes and following cash flows. If initial investment size(cost) increases, the proportion that IRR changes are relatively lower than the percentage that NPV changes. Introducing the concept of fair value, when contractors and investors notice that the government is now constructing nearby cities and towns, they are likely to evaluate the value of cash flows and update the fair value of the project. Under this premise, IRR, which can provide a more accurate estimate of the project, should be chosen so that fair value changes are less dramatic and previous decisions of investors would be more valid.

Overall, when considering long-term effects exerted by external projects or changes, IRR may provide a more valid value than NPV.

2.2 Internal Factor Impact

The second companion of the NPV and IRR rules is under the condition where the projects' cash flow timings and scale are not the same. The discount rate would remain constant and equal for the projects during comparison.

For projects with different scales from each other, we refer to projects with a different amount of initial investment money, which is also known as the cash outflow, noted as C0. Under this circumstance, and for projects with different cash flow timing, we refer to projects with different time lengths that need to wait until the first cash inflow.

Whether comparing projects with different projects scale or with different cash flow timings, NPV always needs to be considered before IRR. This is because NPV reflects the exact value or profit that the investors can gain after a certain time they invest money into a project. While IRR is only a return measurement, we cannot directly tell how much money is made exactly. Since investors are most interested in how much profit they can gain during investing projects, the NPV rule's final value always needs to be considered before IRR's value.

A simple example can help illustrate this condition. We have project A and project B, the discount rate for both projects is the same and is 10%. The initial investments, cash inflow each year, NPV and IRR value will be presented in Table 2 below:

Both projects have IRR that exceed the expected cost of capital which is 10%, the B project has a lower IRR for the possible reason that it may require a higher amount of capital, but it generates a higher NPV. So, when choosing between these two different projects, we priority

consider the NPV then IRR. The NPV reflect properly the size of cash flows related to the project. That's why in this case, we need to pick project B.

TABLE 1. ASSUMED CASH FLOWS OF A SIMULATED TOLLBOOTH PROJECT

Simulated tollbooth project						
Summary/ Time	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cash flows (Project A)	-$1000	$200	$300	$400	$500	$600
Cash flows (Project A')	-$1000	$200	$300	$500	$700	$1000
Comparisons						
NPV (A)	-$115.32					
NPV (A')	$56.43					
IRR (A)	23%					
IRR (A')	33%					

TABLE 2. DATA FOR PROJECT A AND PROJECT B

	Initial investment	Cash inflow each year	NPV	IRR
Project A	$400,000	$250,000	$547,697	56%
Project B	$800,000	$425,000	$811,084	45%

TABLE 3. COMPANY H'S INDEPENDENT PROJECT X

Year	Year 0	Year 1-5	NPV	IRR
Scenario X	-$100	$30 per year	13.7	15.2%

3. EMPIRICAL TEST

To put knowledge into practice, our group contact an industrial company in Guangzhou and finally extracted some useful data about its projects. By discussing with company H, we gained information about some fund-raising projects that are supposed to expand company H's production and complete its industry distribution. In addition, information collected showed that company H produces special vehicles like sanitation vehicles and concrete mixing vehicles. With rising yields, company H can produce a stable cash flow as they have relatively stable customers.

A stand-alone project is a project that exists independently in the investment process, and the project does not affect the decision-making of other projects. There is no mutually exclusive relationship, it can coexist or exist independently, and the project does not affect each other. Based on previous information about Company H, its independent project X needs to decide to determine its feasibility. "Suppose the company wants an expected return of 10%, as shown in Table 3."

As shown from Table 3, NPV is greater than 0, and the project rate of return is higher than expected, while IRR is 15.2% greater than the set capital cost is 10%. It is feasible to use two indicators to judge the results consistently. Therefore, when evaluating stand-alone projects, the conclusions reached using NPV, IRR indicators are consistent. Decision-making judgments can be made based on specific circumstances and project investor preference selection indicators.

Under the constraint of capital constraints or external factors, investors can often choose only one optimal solution among many investment projects, which are called mutually exclusive projects. Conflicting results often occur when mutually exclusive project decisions are made using NPV and IRR metrics. According to information collected, Company H now has two mutually exclusive projects, A and B. Project A's initial investment is $320,000, net cash flow generated each year is $160,000, project life is 3 years, the life of the project must be updated with no residual value, project B needs the initial investment is 420,000 yuan, the project life of 6 years, the annual net cash flow of 120,000 yuan, the end of life must be updated non-residual value. The cost of capital is 10%. Depending on the initial investment in projects A and B, there is a difference of 100,000 years and a difference of 3 years. At this point, the N PV of A is calculated by NPV indicator is 708,000 yuan, the NPV less than B is 933,000 yuan, and the IRR value of project A is 23.38%, but greater than the IRR value of Project B is 20.45%. This shows that the indicator analysis produces conflicts.

In practical application, the main reason for the conflict in decision-making in the analysis of IRR method and NPV method is that the two indicator evaluation methods have different reinvestment assumptions for investment projects: IRR method is that this assumption is unreasonable. Because the return on an investment project overtime may not always be IRR. The NPV law assumes that the net cash flow from the project can be reinvested at the investment project's benchmark rate of return, which is reasonable. In addition, the difference between the amount of investment and the calculation period of the project is also the cause of the difference in results. Evaluations need to be made using the corresponding solution in the light of the situation, rather than relying on individual metrics for independent decision-making.

4. DISCUSSION AND LIMITATION

From the concept and example of NPV, we can summarize its characteristics. Firstly, the calculation of NPV must set a benchmark discount rate. Therefore, its high and low results in different calculations, affecting the judgment of the project. If the discount rate set is too high, the investment project may not pass in advance evaluation, so enterprises lose the opportunity in the market competition. Suppose the set discount rate is too low. In that case, the investment project in the advance evaluation of the benefit preference, after implementation may make the enterprise in the future business activities cannot be profitable. Secondly, the future cash flow of the investment project is certain and is not affected by other factors. However, in the actual complex business activities, the future cash flow is uncertain. Cash flow is often affected by other unknown factors. The NPV results will be different, thus affecting the final evaluation results. Similarly, cash flow is assumed to be predictable in practice.

The internal rate of return is calculated by formula, compared with the benchmark discount rate to arrive at the project's feasibility. This method cannot determine the feasibility of the project and should be based on the actual situation of the project, combined with NPV to judge. For

example, the internal rate of return on a project is less than the benchmark discount rate, but because NPV >0 and the scale of the investment, the annual net cash flow is larger and more valuable. " Furthermore, it assumes that future net cash flows will be reinvested at IRR, which is actually not a good way to reinvest."

5. CONCLUSION

5.1 Background and Methods Used

This paper is mainly an article on NPV and IRR. Both NPV and IRR are concepts in the financial field. Through comparison, analysis and examples, specific research is carried out. In this paper, the NPV and IRR rules are tested under different conditions, and the comparison between the two rules is proved by derivation.

We compared NPV and IRR rules under the influence of external and internal factors. We first consider the impact of the project and then compare when the discount rate is the same, but the project's cash flow time and scale are different from concluding. Through the above analysis and examples, it can be concluded that the two methods have different bases and effects due to the influence of different internal and external factors. We can choose different methods depending on the project's cash flow, the investment basis of investors, and so on.

In addition to comparing the internal and external factors, we use examples to prove the argument. Firstly, we prove that the influence of external factors on the NPV and IRR, in carries on the analysis, reach the purpose of simple. Secondly, under the situation where the discount rate is the same, we compared the two projects, drawing the conclusion. Finally, some examples are given to ensure that the conclusions obtained are true and scientific.

5.2 Conclusions and Findings

NPV and IRR reach different conclusions in different investment scenarios: when investing in independent scenarios, we reach the same conclusions using both methods; When investing in mutually exclusive solutions, we come to different conclusions, that is, solutions with large NVP may not have large IRR, and solutions with large IRR may not have large IRR, resulting in contradictions.

Through the above analysis, we can see that the two are related. NPV value represents an amount, reflecting the data more intuitive. In contrast, the IRR value represents a ratio, and it is high and low to some extent reflect the size of the return on investment. Therefore, the combination of two values is needed to judge the feasibility of an actual investment project to provide more accurate information to decision-makers in the business activities of enterprises.

Both NPV and IRR indicators consider time value and use cash flows as a basis for research. According to the needs of different investors, the analysis of investment decision-making provides different reference standards, which is an important basis for judging project investment decision-making. In general, the optimal choice of using NPV for investment projects can bring more revenue to the enterprise, so the utilization rate of NPV indicators is higher than that of IRR indicators.

When NPV and IRR have conflicts in the direction of investment, they should not be left alone, and we need to deal with them appropriately. We should not adopt a fixed way to make decisions. Such decisions are bound to have an impact on the enterprise's finance. Based on the evaluation results, the reasons and the specific situation should be analyzed. Under certain conditions, one or two indexes need to be selected for analysis and combined with the application to make the investment decision in line with the long-term goal of the enterprise.

5.3 Limitation and Future Study

Since the cash flow data each year is difficult to get directly from the company, the accuracy of the data used in this paper is not high. If possible, cooperation with a certain company enhances the precision of the data and figures.

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