The Scenario Analysis for NPV and IRR in Mutually Exclusive Projects

Jundi Ren[1,*]

[1]*Hult International Business School, 94111, San Francisco, the United States*
[*]*Corresponding author. Email: jren2018@student.hult.edu*

ABSTRACT
In the real world, the project of business decision is relatively long and requires more capital investment, which leads to higher requirements for the feasibility of project investment and scientific decision-making. To improve the science of business decision-making, the application of a series of evaluation indicators and analysis methods to quantitatively analyze the feasibility of the project is a reliable measure. Among countless evaluation indexes, the dynamic indexes are usually more superior when it refers to help make comparisons and decisions between different business projects. The net present value (NPV) and internal rate of return (IRR) are the most used indexes due to their reliability, scientific and representativeness. Normally, the application of both indexes in evaluating the feasibility of an independent project leads to the same conclusion. However, in mutually exclusive projects, the use of these two indexes may result in contradictory results, this thesis aims to analyze the cause of this contradiction from the angle of theory and practice. Compare the advantages, disadvantages, and differences of both indexes. By giving the example of two mutually exclusive projects, analyze how NPV and IRR change under different discount rates, find out the connection among them. In the end, discuss the application of these indexes and ponder the defect of this finding, investigate the future development.

Keywords: *NPV, IRR, Mutually Exclusive Projects, Investment Decision.*

1. INTRODUCTION

The background of this thesis is based on the dilemma of choosing which index to help predict projects' profitability in real life, investors need these data to support their business decision making [1-3]. By comparing the two most commonly used indexes: NPV and IRR, observing the trend of their number in the different discount rates to analyze the advantages and limitations. Based on our research findings, decide when to use these indexes under different circumstances [4-5].

This article is focusing on the scenario analysis for NPV and IRR in mutually exclusive projects. We will give a sample of two mutually exclusive projects to compare their NPV and IRR, analyze how to make investment decisions under different circumstances. We conclude that discount rate is one of the most important influencing factors in this process, different discount rates can lead to multiple types of calculation results and deeply affect business decision making [6-7].

In the beginning, an introduction about the concept and simulation for NPV and IRR will be briefly mentioned, then discuss the applicability for these two indexes. After that, by using an example of two mutually exclusive projects, analyze how NPV and IRR affect the investment decision under different situations. Point out the importance of discount rate, and how it changes the dynamic indexes. The next step, discuss the pros and cons for these two indexes, compare their commons and differences. In the end, the content about the conclusion will include our findings, the defect of this article, and our future research plan.

2. CONCEPT OF NPV

2.1. Applicability

As a basic indicator of the NPV method in project evaluation, NPV is actually the difference between the present value of future capital inflows and outflows. It is the basic indicator of the net present value method in project evaluation. NPV is widely used to analyze the ability of a project of making a profit in capital budgeting and investment decisions [8]. This also means NPV is a prediction of the future stream of payments based on

present value calculation [9]. Since NPV is calculating the sum value of the future stream of payments today, it means if the number of NPV in this project is negative, then all future cash flows under this discounted present value will be negative. In that case, this project or investment will not be encouraged. If the net present value is positive, then the project is feasible. In order to calculate the NPV correctly, we need to determine the right discount rate and forecast the future cash flow under the different periods of time.

2.2. Formula

The formula and calculation used to determine this figure are as follows:

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} \quad (1)$$

The meaning of symbols in the formula is as follows:

C_t = Net cash inflow or outflow during a single period t

i = Discount rate

t = Number of timer periods

n = The number of time periods

2.3. Assumption

NPV is normally used to compare similar investment options. The NPV has a strong connection with the discount rate, which may come from the cost of capital required for the investment. Any project or investment with a negative NPV result is supposed to be avoided. However, an obvious disadvantage of NPV is that its assumptions about the project's changes in the future might be unreliable [10].

NPV aims to evaluate a project's ability to make a fixed profit from the investment. It is based on the fact that the value of one dollar in the future is different from its present value. Due to inflation, money gets devaluation over time. However, one dollar that has been invested today can earn a return, so that its future value may increase. Another NPV's goal is to determine that the present value of future cash flow is higher than the initial cost of the project. If the difference between the initial cost and the sum of current cash flows is positive, then this project is worthwhile. On the contrary, if the NPV is negative, then this project is very likely to face a net loss. Under such circumstances, only those projects with positive NPV values should be put into consideration.

3. CONCEPT OF IRR

3.1. Applicability

The internal rate of return (IRR) is the discount rate when the total present value of capital inflows is equal to the total present value of capital outflows. In other words, the IRR is a special discount rate whose NPV is equal to zero. IRR is the rate of return that an investment aspires to achieve, the higher indicator refers to a more desirable investment. IRR is unified for different types of investment, so it's widely used to rank multiple potential projects based on a relatively equal basis. Investors tend to choose those projects with higher IRR.

3.2. Formula

The formula and calculation used to determine this figure is as follows:

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

The meaning of symbols in the formula is as follows:

C_t = Net cash inflow during the period t

C_0 = Total initial investment costs

IRR = The internal rate of return

n = The number of time periods

In this formula, each cash flow can be positive or negative, it depends on the estimate of project delivery or future capital injection needs. Due to the complexity of the formula, IRR might not be easy to calculate. Usually, it requires calculating iteratively with programming software like Excel.

3.3. Assumption

The purpose of IRR is to find out the best discount rate, to make sure that the sum of cash inflow present value matches the initial net cash expenditure of the project. Generally speaking, if a company is expanding a new project, then IRR is the ideal method to analyze and forecast its return of it. The application of IRR is relatively wide, including comparing the ability to make a profit of mutually exclusive projects, stock buyback programs, and financial decisions.

However, the return of investment usually does not stay the same every year. It is very likely that the actual rate of return is different from the project's estimated IRR, especially for those long-term projects.

4. EXAMPLE CASE STUDY

Taking an example of two mutually exclusive projects: A and B, we have the cash flow for each of them.

Table 1. Cash Flows ($)

Project	CF_0	CF_1	CF_2	CF_3	CF_4
A	-430	230	179	124	94
B	-430	70	138	240	260

Now we can easily calculate the NPV for both projects when its discount rate is 0:

NPV_A = -430+230+179+124+94 = 197

NPV_B = -430+70+128+240+260 = 278

As for the IRR, according to the simulation mentioned above:

$$-430+\frac{230}{1+IRRa}+\frac{179}{(1+IRRa)^2}+\frac{124}{(1+IRRa)^3}+\frac{94}{(1+IRRa)^4}=0$$

So: IRRa = 20.44%

$$-430+\frac{70}{1+IRRb}+\frac{138}{(1+IRRb)^2}+\frac{240}{(1+IRRb)^3}+\frac{260}{(1+IRRb)^4}=0$$

So: IRRb = 18.84%

However, this leads to a very tricky situation: the NPV for project A is higher than B while its IRR is lower.

Clearly, there is a balance point between these two projects: when the discount rate reaches an exact point, the NPV for these two projects doesn't have any difference.

In order to do that, we can use the difference between these two projects to make a new one.

Table 2. New Cash Flows ($)

Project	CF_0	CF_1	CF_2	CF_3	CF_4
A-B	0	160	41	-116	-166

Then calculate the IRR for this new project:

$$0+\frac{160}{1+IRR}+\frac{41}{(1+IRR)^2}+\frac{-116}{(1+IRR)^3}+\frac{-166}{(1+IRR)^4}=0$$

So: IRR = 15.29%

This means: if we want to invest in project A, then we need to make sure its NPV is higher than B, so the IRR must be higher than 15.29%. However, considering that with the increase of discount rate, project A's NPV will decrease, and reaches 0 when the discount rate is 20.44. So, we can choose to project A when its discount rate is between 15.29% to 20.44%.

5. COMPARISON BETWEEN NPV AND IRR

5.1. The advantages and limitations of NPV

NPV puts the time value of investments into consideration and enhances the evaluation of the investment economy. Also, by calculating the net cash flow of the entire business decision-making progress, NPV reflects the unity of liquidity and profitability. Since the main purpose of NPV is the economic benefits of the project after the return of investment in the entire life cycle, it makes NPV a more comprehensive and scientific series economic evaluation method.

However, the use of NPV to measure the project's ability to make a profit is based on the large extent of assumptions and estimates, which means there might also lead to a large margin of deviation. It cannot directly reflect the actual level of income to the investment projects from a dynamic perspective. Moreover, a project may require an additional investment before it starts or needs an extra expenditure after this project is over.

5.2. The advantages and limitations of IRR

One outstanding advantage of the IRR index is that it avoids one difficult and controversial issue: it doesn't need to set a benchmark discount rate ahead. The IRR is not given exogenously in advance but determined endogenously, it's calculated by the project's cash flow. When the base discount rate is not easy to determine its exact value, but only its approximate value range is known, then using the IRR index makes it easier to evaluate the decision of the project.

Another advantage of IRR is connecting the benefit of the project's life cycle with the entire investment, so it will be able to point out the return rate of this project and compare it with the benchmark investment return rate of the industry. This helps determine if this project is worth constructing or not.

However, the disadvantage of IRR is also quite obvious. The IRR index is correct when evaluating a single program. However, when it comes to the multiple programs, if the IRR of two or more programs is directly compared, and the project with a larger IRR is considered to be better than the other project, which may lead to wrong results. This is because though IRR can reflect the possible trend of the profitability of the project, it still failed to accurately analyze the actual data of the project's rate of return. Therefore, the internal rate of return can only be applied to the evaluation of the economics of a single project, and the IRR of two or more projects cannot be directly used to compare the advantages and disadvantages.

5.3. NPV vs. IRR

The pro and cons of NPV and IRR can be analyzed from three different angles.

5.3.1. Mutually exclusive projects

IRR is a relative number, and NPV is an absolute number, so sometimes there would be contradictions. Taking the mutually exclusive projects in the case study

part as an example, the NPV of project A may be less than project B, but the number of their IRR shows the opposite way. There is no doubt that project B should be accepted from the perspective of NPV, but project A should be accepted from the perspective of IRR. It is difficult to make decisions in such a situation.

5.3.2. Non-conventional cash flows

Under traditional cash flow, there is only one exact value of IRR (that is, the project starts with cash outflow, and then the rest will all be cash inflows). However, in a non-traditional cash flow that starts with one cash outflow and multiple cash inflows and outflows, then there may be more than one value of IRR. In that case, IRR is not indicative anymore.

5.3.3. Reinvestment assumption

IRR has a reinvestment assumption. For example, the IRR of a certain project is 40%, and the financing cost of the company is 30%. Then the reinvestment assumption is that the money earned from this project spent on other investments in the market can still earn a 40% rate of return. Yet however, this hypothesis is hard to achieve in real life because it's difficult for us to find projects with the same rate of return of 40% in the market. However, NPV ignores this shortcoming of the reinvestment hypothesis and believes that the money earned by the project can be used in the market. Therefore, the reinvestment hypothesis is a flaw within the IRR itself, because it may overestimate the project's rate of return. If investors take this incorrect information, it is very likely that they would make a wrong business decision.

6. CONCLUSION

Based on the question, there is a contradiction in this model. If NPV is used to judge two mutually exclusive projects, then project B is superior. If IRR is used to judge the two projects, then project A is superior. Clearly, these two approaches clash.

In practical application, the conflict between the IRR method and NPV method is caused by the different assumptions given by the two evaluation methods on the reinvestment of investment projects.

NPV is obtained by a discount of the benchmark rate of return of the project, which indicates that the cash flow of the project in any period has the same opportunity cost as the discount rate of the project, and the net cash flow of the project in any period can be reinvested. This assumption is reasonable.

IRR assumes that the net cash flow from the project can be reinvested according to the internal rate of return of the investment project itself which is unreasonable.

Because the IRR is owned by a single project and has nothing to do with other projects, the return rate of the enterprise's future investment projects may not be higher than that of the project. Each project has its own IRR, and the opportunity cost of cash flow and IRR of each project may not be equal. Therefore, the internal rate of return of the project (like 20.44%) is naturally not representative of the rate of return of other investment projects. Such an assumption results in the earlier positive net cash flow of the project being favorable.

To consultants, if they are using NPV or IRR to write an analysis report, then the change of discount rate must be noticed, for NPV and IRR would also change with it and lead to a completely different result.

In real life, when investors or consultants seek to make a business decision based on the analytics of dynamic indicators, using only one of them is not enough. It's very necessary to think about the positive and negative factors of each index thoroughly, combine multiply indexes' data to make the final decision.

In the concept of NPV, we mentioned that only investments with positive NPV values should be considered. However, in real life, there are still many companies that choose to invest in programs with lower NPV or even negative NPV for many other reasons. Like answers to the government's mandatory policy, developing a potential core program, and customer loyalty. The calculation seems logically right, but it's based on one prerequisite that A and B share the same discount rate at all times. However, in realistic business activities, the discount rate for every project usually won't match with each other at an exact time point. Even if they do, the discount rate will change with market volatility at different speeds and extents, the discount rate it's not a fixed number. In that case, this model will become invalid.

Also, even the answer suggests we shouldn't take project A into consideration when its NPV is lower than B, there are still many companies that choose to invest in programs with lower NPV for many other reasons.

For example, Taobao, run by Jack Ma, is one of the most famous e-commerce platforms in China. In 2004, the first time Taobao went into business, its main competitor is eBay. Unlike eBay's policy, Taobao allows every company to sell their products on its platform without paying a management fee just to gain more companies and customers, for the first two years, Taobao is almost in a deficit situation and the project's NPV is close to zero, even negative. Yet Taobao keeps the promise to their customers and doesn't take any management fee. Things change in the third year, with more and more companies joining this platform, if a company wants their products can be shown on the first page of Taobao searching result, they need to pay the Value-added service fee (one kind of VIP service). With

the change of profit model, Taobao began developing at an unbelievable speed.

The second example is Alipay and WeChat, these two payment channels used to block each other's links in order to protect their business. However, On September 9, the Ministry of Industry and Information Technology of China held an "Administrative Guidance Meeting on Blocking Web Site Links", requiring all platforms to unblock website links in accordance with the standards on September 17, otherwise, they will take measures in accordance with the law.

As we can see, this mandatory policy will harm these companies' interest and leads to a lower NPV, they still need to answer the government's requirement and take it.

In real life, also investors seek to achieve the maximum benefit as what analysis report suggests, they still need to put other limit factors into consideration. Sometimes, the temporary deficit is for the long-term profit, especially for the internet industry.

The change of business environment is getting more rapid and dramatic, it won't be scientific for investors and consultants getting too superstitious about the calculation. Taking data only as guidance, making a business decision based on real conditions in a flexible way is the best idea.

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