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The Development and Usage of NPV and IRR and Their Comparison

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ABSTRACT
Net present value (NPV) and internal rate of return (IRR) are two popular capital budgeting techniques in the modern economy. Almost all finance textbooks included these two concepts. The paper presents a review of NPV and IRR from the following perspectives and aims to provide a general understanding of NPV and IRR for the audience. The development of NPV and IRR will be discussed in this paper. The disadvantages and advantages of NPV and IRR will also be presented with detailed examples. The utilization of NPV and IRR in three counties, the United States, Finland, and Japan, is discussed to offer an overview of companies' preference of decision methods in these three counties.

Keywords: *Net present value, Internal rate of return, Capital budgeting techniques.*

1. INTRODUCTION

Capital budgeting is an important process for a company. It aims to choose projects or investments that can benefit the company. Examples of capital budgeting decisions include whether taking one project is worth more than taking the other project, whether opening a new store is valuable for the company, and whether purchasing a new machine or new software is a good decision.

Capital budgeting includes the following process: 1) ascertaining the initial cash outflow, 2) estimate future cash flows and the life span of the project, and 4) determining which decision rules to use. The most popular and widely used capital budgeting methods include net present value (NPV) and internal rate of return (IRR), and universities always teach them.

This paper, therefore, discusses these two common methods in terms of development, advantages and disadvantages, and utilization of NPV and IRR in different countries such as the United States, Finland, and Japan.

The rest of the paper is composed of four sections. Section 2 introduces the development of NPV and that of IRR. Section 3 discusses the advantages and disadvantages of NPV and IRR. Section 4 presents the usage of NPV and IRR in different countries. Last, Section 5 will conclude the main

2. THE DEVELOPMENT OF NPV AND IRR

2.1. The Development of NPV

Net Present Value refers to the current value of a stream of future payments. The formula for NPV is,

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

where R_t is the cash flow during period t, i is the discount rate, and t is the number of project periods.

The decision rule of using NPV as a capital budgeting technique is to accept the project or investment if the NPV is the project or investment is positive and to disdain the project or investment if the NPV is negative.

Although the NPV method is widely used in companies as a decision technique, the popularity was relatively late compared to other capital budgeting tools. Behringer concluded that the ban on interest in religious and philosophical conflicts is the major factor for that [1]. Arthur. M. Wellington, an American civil engineer, wrote the book *The Economic Theory of the Location of Railways* in 1877. He utilized the present value method to analyze the decision of whether a line should not be built [2]. Fisher and *Principles of Engineering Economy*, written by Eugene L. Grant (1950), contributed to the development and popularity of NPV.

2.2. The Development of IRR

Internal rate of return refers to a rate that makes the net present value of all cash flows equal to zero. The formula for IRR is,

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

Where t is the number of time periods, C_t is new cash inflows during the period of t, C_0 is the initial cash outflow.

It is a financial technique helping estimate the potential profitability of an investment. If the IRR of a project of investment is less than the opportunity cost of capital, we accept it, and if IRR is greater than the opportunity cost of capital, we reject it. When we talk about the IRR, we can go back at least to Irving Fisher [3]. In his book *The Theory of Interest*, he introduced the concept of "the rate of return over cost" by representing two alternative investments. The discount rate of these two investments makes the difference of present values of the two investments, as denoted by 1 and 2, be zero, and the difference is indicated in the following equation with R(t) represents inflows and E(t) represents outflows [4],

$$\int_0^t ([R_1(t) - E_1(t)] - [R_2(t) - E_2(t)])c^{-rt}dt \quad (3)$$

Keynes [1936] named IRR as the marginal efficiency of capital and maintained that it is the same as Fisher's marginal rate of return over cost [5].

2.1.1. Modified Internal Rate of Return (MIRR)

During the seventeenth and eighteenth centuries, the popularity of quantification spread across Europe. Influenced by this trend, Duvillard invented an investment evaluation measure similar to the modern modified internal rate of return. His analysis built on the rate of return of the equivalent deposit, while the modern one defined MISS as the rate that makes the future value of initial investment invested at MIRR equal to the rate at which the future value of the sequence of annuities are invested [6]. MIRR is a similar capital budgeting technique to IRR and is designed to solve the problem of multiple IRRs, which will be covered in section 3.2. The formula of MIRR is,

$$0 = NPV = \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} - C_0 \quad (4)$$

The main difference between these two concepts is that IRR assumes reinvesting cash flows at the IRR rate, while MIRR assumes reinvesting cash flows at the firm's cost of capital. If MIRR is higher than the expected rate of return, project managers should accept the investment and vice versa.

3. COMPARISION

This section will discuss the advantages and disadvantages of NPV and IRR, respectively.

3.1. Advantages and Disadvantages of NPV

NPV is taught in most textbooks in the finance courses at universities. There are three main reasons why textbooks favor NPV, even given that most firms prefer to use IRR as their decision rule. The first reason is that the NPV rule assumes that a dollar today is worth more than a dollar tomorrow because people can invest money they hold today and earn interest in tomorrow. In NPV calculation, all future cash flows are discounted by returns in each period, and the sum of the present value of all future cash flows is the project's net present value. Moreover, since NPV is measured in numerical format, shareholders can clearly know how much value they can obtain from the project or investment. NPV is also presented in current dollars, and thus project managers can all NPV of different projects up. The sum of NPVs of projects A and B is,

$$NPV(A+B) = NPV(A) + NPV(B) \quad (5)$$

By adding them up, managers can infer that if the sum of the NPV is lower than individual NPV, the project those drags the total NPV down is identified as a poor project.

The last advantage of NPV is that it assumes that future cash flows are reinvested at different rates overtime periods. It makes sense that discount rates should differ over time since the economic situation differs from year to year.

However, estimating discount rates is difficult and time-consuming, which is one disadvantage of the NPV rule. Any wrong estimation would cause a wrong result in NPV, and therefore the final decision may not be accurate. Although it might be easy to estimate the cost of new equipment, technologies, and materials, the estimation for depreciation of old equipment and cost spent on employees may be hard to estimate. This causes a large variance between actual initial investment and estimated initial investment.

Another disadvantage is that NPV fails when comparing projects with different sizes. A large project, say $10 million, definitely generates a higher NPV than a $1 million project. However, it is also possible that the percentage return of the smaller project is higher than that of, the larger project. Even though firms can earn more from the larger project, initial cash outflow is an important problem that cannot be neglected. Firms usually need to borrow from financial institutions to fund the project.

3.2. Advantages and Disadvantages of IRR

Compared with NPV, which requires the cost of capital for the different time periods, IRR is simple to use and intelligible. Without estimating the cost of capital, using the IRR method can reduce the risk arising from the wrong estimation. IRR is easy to communicate and provides a straightforward percentage number of how many returns a project or investment can generate. Since IRR gives a percentage of the profitability, it is easy to compare it with a required rate of return and other projects. Moreover, IRR takes the concept of the time value of money into consideration. IRR uses a single rate to discount each future cash flow back to its present value.

When using the IRR decision rule in project evaluation, we often assume that the project generates positive cash flows during its duration. However, the reality might not always be satisfied with this assumption when a project has a non-conventional cash flow pattern, which means that cash flows of the project change sign more than once, the problem of multiple IRRs arises. Lorie and Savage first described this kind of pitfall in the example of the pump problem, in which 2 IRRs occur [7]. To illustrate the problem of multiple IRRs in more detail, an example is given in Table 1, and the graph of NPV with respect to discount rate is presented in Figure 1 for visualization purposes. A company is considering a project with a life of 5 years that cost it $300 at the beginning. Project managers believed that the project could generate money during its lift time: $200 from year 1 to year 4, while in year 5 the company should pay out $520 to get the project done.

Table 1. Problem of multiple IRRs

Cash Flows ($)					
C_0	C_1	C_2	C_3	C_4	C_5
-300	200	200	200	200	-520
IRR_1 = 4.43%		IRR_2 = 26.18%			

Figure 1. Problem of multiple IRRs

The example shows that the project has 2 IRR, 4.43%, and 26.18%, which makes the NPV of the project equal to zero. The multiple IRRs make project managers reach a deadlock; she or he gets confuses about which IRR should be used to compare with the hurdle rate, a minimum rate of return of a project must earn to offset the costs of the project.

Since firms usually have constrained budgets and resources, which means that their available budgets and resources may only support them to complete one project, they have to decide on mutually exclusive projects. This comes to another disadvantage of IRR, mutually exclusive projects.

Let us take another example. Assuming projects A and B are mutually exclusive projects, meaning that the firm can either accept A or B and cannot accept both projects simultaneously. Initial cash flows and subsequent cash flows are presented in Table 2. IRR for project A is 20.44%, and IRR for project B is 18.84%. We further assume that the discount rate is 10%, and we get NPV for project A is $84.39, and NPV for project B is 105.59. According to the NPV rule, we should accept project B since it has a higher NPV than project A; however, we should accept project A since it has a higher IRR, indicating that A generates a 20.44% rate of return.

Table 2. Problem of mutually exclusive project

Cash Flows ($)							
	C_0	C_1	C_2	C_3	C_4	IRR	NPV at 10%
Project A	-430	230	179	124	94	20.44%	84.39
Project B	-430	70	138	240	260	18.84%	105.59

The difference between NPV and IRR has been discussing for a long time. One of the outstanding explanations is called reinvestment assumption. IRR has

a reinvestment assumption that presumes that the company reinvests intermediate cash inflows at the rate equals to IRR, while NPV assumes reinvesting at the cost of capital. Kalhoefer proposed another explanation, which is called "an inconsequent application of the two methods". He stated that projects with different cash flow patterns are not comparable directly [8]. Thus, IRR fails when ranking two mutually exclusive projects and produce different results.

4. USAGE OF NPV AND IRR IN DIFFERENT

Although most companies over the world prefer NPV rather than IRR [8], the usage of NPV or IRR can be different on a country-by-country basis. This section will present the usage of NPV and IRR in several countries, the United States, Finland, and Japan.

4.1. United States

In 1977, Gitman and Forrester investigated 268 large firms by sending questionnaires to CFOs, with "large" being identified by stock price growth and total dollar of capital expenditure. 53.6% of companies indicated that IRR was their primary capital budgeting technique, whereas 9.8% of companies indicated that NPV was their primary tool [9]. Graham and Harvey conducted a survey among all Fortune 500 companies and got 392 returned responses. The result indicated the frequencies of the utilization of IRR and that of NPV were almost on a par: NPV was always or nearly always used by 74.9% of CFOs, and IRR was always or nearly always used by 75.7% of CFOs [10]. Compared with NPV, which requires the cost of capital for a different time.

4.2. Finland

NPV has been taught at least from the 1980s at business schools in Finland [11]. The history is shorter than that in the United States. In 1975, the study conducted by Honko and Virtanen reported 43.5% of corporations in Finland adapted IRR as the primary technique, while there was only 6.5% of corporations utilized NPV as the decision rule. In 1984, the study conducted by Virtanen reported 57.7% of corporations considered IRR as their major indicator, while only 2.5% utilized the NPV rule [12]. However, as time goes by, more and more candidates of project managers learn NPV as a more sophisticated capital budgeting method, the popularity of NPV is increasing. In a survey conducted by Liljeblom and Vaihekoski in 2004 [11] by collecting and analyzing questionnaire of 46 listed companies listed on the Finnish stock exchange, HEX Ltd reported that IRR is one of the most popular methods. NPV indeed gain more attention: 52.1% of selected companies stated that they use the NPV either as their primary or secondary decision rule of an investment [11].

4.3. Japan

NPV and IRR are also widely taught in universities in Japan, while usage of capital budgeting techniques is different from the countries above. Shinoda did a survey by sending a questionnaire to 2,224 companies among xx listed companies on the Tokyo Stock Exchange in Japan to explain capital budgeting methods used by Japanese companies. Within 225 responses, Shinoda discovered that 30.5% of selected companies claimed that they always often use NPV as their decision rule. The result makes NPV the second favorable decision method for Japanese companies, followed by the simple payback period method. The rank of IRR is closely behind NPV, with a rate of 24.5% of companies always or often using the IRR method [13]. Shinoda's survey results indicated an advocacy for NPV and IRR method as the ranking of NPV and IRR both increase compared to the survey did by Tsumagari and Matsumoto. Takahashi et al. Hanaeda also did a survey. The results showed that payback period and accounting rate of return are the top two favorable methods, followed by NPV and IRR. He contributed less popularity of NPV and IRR to a lower education level of CFOs in Japanese companies than CFOs in countries like the U.S. [14].

5. CONCLUSION

In this paper, I have discussed the development of NPV and IRR. Then, several advantages and disadvantages of NPV and IRR are presented with some examples to illustrate problems in detail. This would give some ideas for the audience of which method they should choose to use based on their own preference or tastes and the analysis of a project or investment. The paper also discussed the utilization of NPV and IRR in three countries, the United States, Finland, and Japan. The previous studies examining capital budgeting practices in these countries indicated an increasing trend in using both NPV and IRR methods. In the United States and Finland, managers show more interest in the IRR method, while in Japan, managers prefer NPV rather than Japan. This difference makes sense as economics circumstance is different from country to country.

The paper is at least leave one question. Although the utilization of NPV and IRR methods is different in countries and previous studies offer a general conclusion of preference of the usage, the utilization may be influenced by industries. In further studies, it would be a good choice to include an analysis of the utilization of NPV and IRR in different industries.

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