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Analysis of the Net Present Value and Equivalent Annual Cost in Optimal Machine Life

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ABSTRACT
Both net present value (NPV) and equivalent annual cost (EAC) are appropriate methods for modifying an investment project. While Net Present Value may assist investors in evaluating the project's cash flows, EAC illustrates the cost of several projects over a year. The purpose of this research is to discover whether one of the two metrics, NPV or EAC, is superior. Net Present Value is the difference between the present value of cash flows and the present value of cash flows after a period. The annual cost of ownership, operation, and maintenance are equivalent. To establish whether NPV or EAC is the more appropriate technique for adjusting investment projects, this essay use them to estimate the optimal machine life. After evaluating the calculation procedure for this issue and using these two approaches, the findings indicate that EAC is more appropriate for investment projects with varying durations. These findings imply that net present value is more appropriate for estimating the cost of a project over a specified period; thus, when dealing with investments with varying life spans, equivalent annual cost is a better option than net present value.

Keywords: *Net Present Value, Equivalent Annual Cost, Optimal Machine Life*

1. INTRODUCTION

The equivalent annual cost is a crucial method for capital budgeting for a company and can also be used to compare different projects with a different lifetime. This model can compare and determine the best project by using the net present value (NPV). This method aims to calculate the current value of the future cash flow of the project we choose.The formula of NPV is NPV=CF / [(1 + r)^n]. CF represents future cash flow, and r represents for discount rate. Normally, the higher net present value indicates that the project is better to be chosen. We usually accept the project whose net present value is positive. Based on these, managers can have more accurate predictions on the different projects with different periods.

Evaluation of a project is crucial for investors to make decisions. It is also significant to do research based on the academic results for the relative evaluation process. Accordingly, several previous studies focused on comparable evaluation measures instead of considering the time value for a specific project.

For a direct insight of the comparable evaluation method, it compares the target company to its peers in the same industry and implies what it is worth based on appropriate relative trading multiples. The comparables group should share key financial characteristics, market prospects, business motivations, and potential risks [1]. Relative valuation methods are used frequently since they are quick and easy to deal with [2]. Comparable methods give investors a starting point on whether they want to investigate more into the industry as a whole.

However, drawbacks of comparable measures do exist. This analysis is complicated and time-consuming in real-life scenarios because investors have to manually search through each company's filings and search for the market indicators rather than relying on automated services. Moreover, investors have to decide whether an expense is non-recurring and make adjustments for the company's financial figures. Additionally, according to Kung-Cheng Ho, et al., comparable evaluation methods are inaccurate and subjective when a similar group experienced fluctuations. It is hard to take time value and direct approaches into considerations. Thus biases do exist.

The immediate solution to this problem is the net present value method. NPV is the difference between the present value of cash inflows and that of cash outflows over some time. This method could be well used for analyzing the profitability of an investment in a company or a new project for a firm. The apparent advantage of the net present value method is that it considers the basic idea, discount rate. It can be concluded that a future dollar is worth less than a dollar today. In each period, the cash flows are discounted by another period of capital cost. The NPV also tells us whether an investment will create value for the company or the investor. It can help investors make decisions in many ways. Like many methods in finance, it is not the faultless solution—it carries a few unique disadvantages that may not make it useful for some investment decisions. The biggest limitation to the net present value method is that the NPV is not useful for comparing two assets of different sizes because the size of the net present value output is determined mostly by the size of the input.

2. DATA

The equivalent annual cost model is an important method when doing capital budgeting and comparing different projects with different lifetimes. The most typical application calculates the optimal machine life using the NPV methods. In this paper, we base on an example of calculating the optimal machine life to analyze further related concepts.

The example is about a single machine on a project used to produce output. The purchase price of the device is 300. And technically, this machine lasts three years and would yield a cash inflow of 200 each year. However, the cost of maintenance increases with the age of the machine. Table 1 shows the costs along with the salvage values in detail. Assume a constant discount rate of 10%.

This example is about how much cash flow the machine will generate as time goes by and how long we should operate to maximize the cash flow. Based on the cash flow and maintenance costs, we can calculate the cash flow of each year.

Then, it also needs us to determine how long the company should plan to operate the machine in question 1 and the optimal machine life when it can be repeated only once in question 2 and infinitely many times in question 3. We will calculate them by using the net present value and equivalent annual cost model in Table 1.

Table 1. Data of the example of optimal machine life

	T1	T2	T3
Maintenance costs	35	65	125
Salvage value	240	165	114

3. METHOD

This method introduces the basic information of Net Present Value (NPV) and Equivalent Annual Cost (EAC), also including the calculation process of these two methods. In addition, the actual application of EAC and NPV has been found out to help us analyze which one is more suitable for each case.

3.1.NPV (Net Present Value)

NPV is the cash inflows and the present of cash inflows and outflows over a specified time period. [3]. The NPV model is as follows.

$$NPV = C_0 + PV = C_0 + \sum_{n=1}^{T} \frac{C_t}{(1+r)^t} \quad (1)$$

C_0 = the cash flow at time 0

C_t = the cash flow at time t

PV = present vale

t = number of time periods

r = Discount rate or return that can be earned in alternative investment

3.1.1.Application of NPV:

It is a proper tool to evaluate investment projects. The research from Keswani and Shackleton shows that NPV can be used to ensure effective project management and can and should be applied to continuously check the health of the project[5].

Additionally, even during times of project instability, it can be a critical tool for determining the most suitable solution.

Wetekamp found that NPV and other pricing models can show how a project's option value increases with incremental levels of investment and disinvestment flexibility [12]. From his research, NPV and other pricing models proved that consideration of exit strategies by management at the project's inception may bring value.

3.2.EAC (Equivalent Annual Cost)

EAC is the annual cost of ownership, management, and repair of an asset throughout its useful life [4]. The Formula is as follows.

$$EAC = \frac{\text{Asset Price} \times \text{Discount Rate}}{1-(1+\text{Discount Rate})^{-n}} \quad (2)$$

n = number of periods

Calculation Process:

Step 1: Calculate the net present value of cost for each potential replacement period.

Step 2: Calculate the equivalent annual cost for each potential replacement cycle.

Step 3: Choose the replacement cycle with the lowest equivalent annual cost. Other factors may also have to be concerned [4].

3.2.1.Application of EAC

EAC can reduce the number strategy and evaluate cost-optimal strategies.

The comparison of short-term and long-term methods is made sure by expressing them as an annual interest weighted anticipated expenditure. This study uses EAC to determine the most effective technique for mitigating flood risk [9].

In addition, it can be used to compare the cost of multi-use medical devices. The expenses of multi-use infusion pumps are not directly comparable because they have different operational cost and life span. EAC of each pump should be calculated. It can represent the annual cost of owning and operating the pump over the entire life span. Doctors who understand the EAC method may make cost-effective decisions on comparable devices using standard capital investment methods [10].

4. NUMERICAL ANALYSIS

It says that a company needs a machine which costs 300, and then its life is 3years if there is no maintenance. It can provide a cash inflow of 200 each year. As shown in the chart, the maintenance price and salvage are different. Also, the discount rate is 10%. Question 1 requires to use NPV to calculate the optimal machine life if there is no maintenance. The equation present value = cash flow * 1/r*[1- 1/(1+r)^T] will be used. Firstly, The cash flow table could be made based on what we already know from the question. And then, it is necessary to use a discount rate to move each cash flow in year 123 to the beginning. Finally, the net present value can be calculated. By comparing, year 3 NPV is the largest, and it is the best machine life (Table 2).

Table 2. Different NPV value of the project.

	0	1	2	3	NPV
Y1	-300	240- 35+200			-300+405/1.1=68.18
Y2	-300	200-35	165- 65+200		-300+165/1.1+300/1.1^2=97.93
Y3	-300	200-35	200-65	114-125+200	-300+165/1.1+135/1.1^2+189/1.1^3=103.568

Question 2 is similar to question 1, which assumes that the project can be repeated once. Based on the previous question, the cash flow of question 2 can be illustrated. First, use the backward induction and start with the second cycle; Second, calculate the discounted cash flows; and third, find the optimal year in the first cycle. With this logic, we can use this formula to calculate the net present value in the second cycle. For the fourth period-t4, the current cash flow is still 405 as period 1, but it also includes the 103.567 part, so we should discount them both. Similarly, we can calculate the NPV of periods 5 and 6. Afterward, we compare and decide the optimal one. As the mathematical result is largest in period 5, the optimal machine life is 5 years. The NPV is 183.527 (Table 3).

Table 3. Different NPV value of the project in other period.

	0	4	5	6	NPV
Y4	-300	405+103.568			162.335
Y5	-300	165	300+103.568		183.527
Y6	-300	165	135	189+103.568	181.381

Question 3 assumes that the project can be repeated infinitely many times. Also, based on the hint, we can clearly find out that we should compare the cash flow by using the equation of PV of the annuity. The equation present value = cash flow * 1/r*[1- 1/(1+r)^T] will be used. Then we can calculate the cash flow of each year by using the npv given in question a. The data shows that we will get the highest cash flow if we replace it once a year. Finally, it becomes a perpetuity question to calculate the overall NPV. We will use the equation below. And the npv equals 750.

Table 4. The cash flow of the project.

	0	1	2	3	NPV	Cash flow
1	-300	405			68.18	74.998
2	-300	165	300		97.93	56.41
3	-300	165	135	189	103.568	41.646

Pv= CF/r=75/10%=750

5. DISCUSSION

Currently, we have discussed the methods of NPV and EAC, their mathematical procedures, as well as how they could be efficiently applied in real-world project management cases. In part 4, we also apply the theoretical methods to help with the project selection issue for a real company.

Based on the existing research, we realized it is important to develop innovative insights and extensions. One possible extension in this essay is the adjusted NPV method, which pluses the flexibility in investment decisions to the standard NPV calculations. We propose simple models for the analysis of the investment decision under uncertainty. To be specific, we could use the Merton model of capital market equilibrium with incomplete information to determine the appropriate rate for discounted future risky cash flows in the case of information asymmetry. Apart from this, we can also review the main potential applications of option pricing theory to the valuation of real complex options. Accounting for the effects of information uncertainty and information costs, we can achieve a closer result to the practical case.

6. CONCLUSION

In this paper, we mainly focus on calculating the optimal machine life model and its application based on the related sample questions. According to further research, we extended the concept of the equivalent annual cost (EAA) model, which can be used to calculate the optimal machine life and capital budgeting. After giving a brief description of the definition, we focused more on the advantages, limitations, and applications of EAA. Besides, the NPV method used in this model is also analyzed in this paper.

By researching two distinct approaches, net present value and equivalent yearly cost, both investment strategies can be utilized to assess successful investment project management. But the equal annual cost is used to compare the equipment or projects after their original life. Also, the projects with various lifetimes may be quantified by equal annual cost. At the same time, net present value can only determine the worth of a project in a certain time. As a result, when dealing with investments that have a varied time horizon, we prefer to employ equivalent annual costs.

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