Research on the Application of EAA and EAC

Jiaxin Cai[1a]

[1]Finance, South China Agricultural University, Wushan Street, Guangzhou, China
202018710501@stu.scau.edu.cn

Abstract

When there are multiple investment projects, those who have the opportunity will usually choose the investment through calculating the net present value（NPV）, and if an investment has the biggest net present value, then it will be the optimal investment. When the life of investments is the same, we can utilize net present value to determine the best machine life. However, when the machine has different ages, it is impossible to make investment choices by calculating net present value. The study found that when there are projects with different investment years, it can be calculated by the equivalent annuity method and the investment value annuity method. Therefore, the main purpose of this article is to introduce the concepts of equivalent annual annuity（EAA）and equivalent annual cost（EAC）, and to study the use of these in real life, all walks of life and various industries. There is still a lot of white space, and the actual use is very frequent. Therefore, the use of equivalent annual cost in real life will be more extensive. When there is a new project, the cost between the new and old projects should be evaluated by calculating the equivalent annual cost, so as to make frequent choices. Both EAA and EAC are used to evaluate various projects with different investment years or service lives. EAA is calculated from the perspective of profitability, while EAC is considered from the perspective of cost. Research on these two will not only be of great help in the field of investment, but also will be a great progress in project evaluation and research and development in all walks of life.

Keywords: *the optimal machine life; equivalent annual annuity; equivalent annual cost; net present value; investment.*

1.INTRODUCTION

In the financial field, we often need to compare the optimal investment projects by means of calculation, so how do we generally measure and compare these investment projects? In general, calculating the return on an investment project entail taking into account both expenses and benefits. Net present value and equivalent annual annuity are two indications for measuring the return on an investment project. The highest net present value and equivalent annual annuity are the investment projects with the highest returns. Equivalent annual cost from the perspective of cost, the small investment project of Equivalent annual cost EAC is the investment project with the lowest cost. Today, net present value is a widely acknowledged measure for valuing a company's investment. Net present value was established and popularized very late in comparison to other management strategies. Compound interest is regarded as a major obstacle to its development, as it is required for computing net present value (NPV) [7].

Table 1: comparison of NPV, EAA and EAC.

COMPARISON OF NPV, EAA AND EAC		
Method	Formula	Advantage
NPV	$NPV = \sum \frac{Year\ n\ Total\ Cash\ Flow}{(1+Discount\ Rate)^n}$ (1)	Net present value refers to the present value of cash flows at the required rate of return on the project in relation to the initial investment. Most financial analysts use net present value (NPV) as their primary tool. This is due to two factors. To begin, the time value of money is taken into account by translating future cash flows into today's value. Second, it

G. Vilas Bhau et al. (Eds.): MSEA 2022, ACSR 101, pp. 787–793, 2023.
https://doi.org/10.2991/978-94-6463-042-8_112

		provides managers with a quantitative figure to compare the original cash spent to the return's current worth [1].
EAA	$EAA = \frac{r \times NPV}{1-(1+r)^{-n}}$ (2)	When comparing investment projects with different years, it is not possible to only calculate NPV, but to calculate through EAA. In addition, when there are projects with short lifespans that want to be reinvested, the use of NPV cannot take into account the income of reinvestment. Therefore, the use of EAA can also better take into account the reinvestment situation.
EAC	$EAC = \frac{NPV}{A_{t*i}}$ (3) $A_{t*i} = \sum_{t=1}^{t^*} \frac{1}{(1+i)^t} = \frac{1-(1+i)^{-t*}}{i}$ (4)	The concept of EAC is a supplement to the classic NPV rule, with its own set of advantages. For example, it assists us in determining costs in a broad sense and identifying alternative funding options such as debt and lease finance [9].

We can see that EAA and EAC are calculated on the basis of NPV, so EAA and EAC make up for many shortcomings of NPV, such as investment income, average cost, etc. (Table 1) Furthermore, while net present value is better for projecting the cost of a project over a certain time period, comparable annual cost is a better alternative when dealing with assets with varied life lengths than net present value [2]. Based on it, this article will introduce EAA and EAC in depth, from the definition of EAA and EAC, the derivation of the formula, the usage of the formula, the limitation, the application in all walks of life, and the current research situation, hoping to further deepen the research on EAA and EAC. And also allow more readers to understand the advantages of EAA and EAC, stimulate more scholars' interest in studying EAA and EAC, and fill the current gap in this field. At the same time, I hope this article can help more people understand EAA and EAC, so that EAA and EAC can be more widely used in all walks of life.

2.EQUIVALENT ANNUAL ANNUITY (EAA)

2.1. Definition

Investment projects with varied lifespans are evaluated using Equivalent Annual Annuity (EAA) calculations. This approach might help an investment analyst or portfolio manager uncover better investment possibilities when comparing two investments with differing maturities. Generally, investments are evaluated by comparing risk and reward. Long-term investments are riskier because they take longer to return to investors. As a result, before making a final purchase choice, the length of the investment must be considered. Because longer-term investments are frequently riskier, it can be difficult to evaluate return values when an investment has two distinct maturities. Equivalent annual annuities compare multiple opportunities of different durations set into one year. The EAA method calculates the fixed annual cash flows a project generates during its lifespan, converting returns into equal annual interest rates so that all investments may be compared and valued on comparable terms (if it is an annuity). Investors should pick initiatives with a greater EAA when comparing ventures with unequal lifetime.

For example, if an investor has to choose between two investments, both of which are $400,000 (USD), he needs to know how long both investments will provide value before he can make final decision. The first investment period is six years and the second investment period is four years. Since the second type of investment has a shorter duration and less risk, the rate of return is lower. This decision is obvious for investments with the same initial investment value, but becomes more challenging when the two amounts are EAA calculations provide analysts with a way to compare the value of different investments over different time periods by comparing total costs. The lowest cost investment is the best option. Example: If one investment is measured at $5000 and another is measured at $2500, the second investment is the better deal because it has the lowest annual cost. The actual calculation is complicated. The two variables are the present value cash flow (PV) and the annuity factor. Specifically, a business annuity is calculated by dividing the present value by the annuity factor. The annuity factor is determined by the following formula:

$$1/r - 1/r\ (1 + r)\ \hat{}\ t \qquad (1)$$

where r is the rate of return or discount factor and t is the time period. Investments with larger present values and/or the lowest annuity coefficients have the lowest cost. Furthermore, while net present value is better for projecting the cost of a project over a certain time period, comparable annual cost is a better alternative when dealing with assets with varied life lengths than net present value. It’s also worth mentioning that similar annuities can be used to compare two things to see which is more tempting.

As another example, suppose a company has the option to work on two different projects; where Project 1 has a 7-year duration and Project 2 has a 16-year duration. If both projects have the same net present value (NPV), the 7-year project will have a better rate of return due to its shorter duration and higher yearly annuity.

As a result, the equivalent annuity approach is one of two techniques used in capital planning to analyze mutually incompatible assets with uneven lifetime. Investors should prefer projects with greater equivalent annuities when comparing projects with uneven lifespan. Using standard present and future value calculations, analysts typically use financial calculators to find business annuities.

Shorter-term investment spans can also be reinvested using the NPV approach, and the profit on reinvestment isn't taken into consideration. This similar annual annuity formula eliminates the need for reinvestment at the current investment's yield, allowing for relative temporal comparison. As a result, similar annuities account for reinvestment, whereas NPV does not.

Here is the formula for EAA.

$$EAA = \frac{r \times NPV}{1-(1+r)^{-n}} \quad (2)$$

When the current value is given, the comparable annual annuity formula employs the annuity payout formula. To produce a value relevant to the usage of the equivalent annuity formula, net present value replaces present value.

2.2. Equivalent Annual Annuity Formula Example

Using the preceding example, comparing the 4-year period of one project to the 15-year period of another project, the 4-year one-year project has a net present value of $100,000, while the value is $150,000 in the 15-year project. The ratio is 8 percent. When the variables from the variable 4-year project and 15-year project plan are entered into the comparable annuity formula, the former has a higher return on investment than the other two projects. Despite the fact that there is a greater NPV in the 15-year project, the 4-year project can be reinvested and yield more benefits over 11 years, allowing the 15-year plan to be followed. In capital planning, the similar yearly annuity approach is used to determine the net present value of a project with equal cash flows across the investment period. An investment with an unequal cash flow is represented by the Net Present Value (NPV) formula. When utilizing the net present value approach to compare two separate investments, the length of the investment (n) is ignored. An investment with a 15-year tenor may have a larger NPV than one with a four-year tenor. The equivalent yearly annuity formula evaluates the investment's lifetime by expressing NPV as a series of cash payments.

2.3. Second Section

When comparing two new projects, the Equivalent Year Annuity calculation comes in handy (one having a term of 15 years and the other with a period of 4 years). Assume that the NPV of both projects is the same. The 4-year project will have a faster return when utilizing the equivalent annuity computation, resulting in more cash flow. Evaluating different investments may not always be easy in real life, thus this method should be employed.

Another rationale for utilizing the equivalent annuity calculation is that shorter-term investments can be reinvested, whereas the NPV technique does not account for the return on reinvestment. This similar annual annuity formula eliminates the need for reinvestment at the current investment's yield, allowing for relative temporal comparison.

2.4. Second Section

EAA can be used to choose the optimal machine life, If we do not know the service life of the machine, that is, we assume that the machine can be used indefinitely, then only calculating NPV can no longer make a choice. At this time, we should analyze this type of analysis from the perspective of EAA. Suppose the project holds period T, which means that people receive money equal to EAA in each period. After period T, the discounted value of all my cash flows is the same as npv. Because EAA means that the cash flow is the same every year.

Furthermore, the impact of changing the CDR on the EAA is identical for discount rates of 0.5 and 2%. EAA levels in stands with high to average site index values or high to medium cork quality attributes are associated to CDR of 9 and 11 years. The CDR variation had no effect on EAA variation in stands with low site index values and/or low cork quality features. In simulations done with a 5% discount rate, the EAA decreases as CDR increases, indicating that the smallest permitted number for CDR should be chosen, which is 9 years [6].

3.COPYRIGHT FORM

3.1. Definition

The Equivalent Annual Cost is the annual cost of holding, producing, and helping to maintain an asset over its entire life cycle (EAC). Businesses typically utilize the EAC to make capital budgeting decisions since it allows them to compare the cost-effectiveness of different assets with different lifespans. Let's look at the Equivalent Annual Cost (EAC) in more detail next.

The Equivalent Annual Cost (EAC) is a financial metric that may be used to a variety of scenarios, including financial forecasts. It is most typically used, however, to evaluate two or more potential projects with various life expectancies, with cost being the most relevant factor.

The EAC's other applications include calculating an asset's optimal life, determining whether renting or purchasing is the best option, determining the extent to which maintenance costs influence the asset, determining the cost savings required to sustain the cost of a new asset, and determining the cost of keeping current infrastructure.

The discount rate, sometimes known as the cost of capital, is a factor in calculating EAC. To make capital budgeting projects like construct a new plant worthwhile, the requisite return on capital costs is required. The cost of capital, which comprises the cost of debt and the cost of equity, is used by businesses to determine if a capital project is worthwhile.

Companies frequently utilize the EAC to make capital budgeting decisions since it allows them to compare the cost-effectiveness of different assets with different lifespans. Managers can use EAC to assess the net present value of various projects over time to find the optimal decision.

3.2. Equivalent Annual Annuity Formula Example

The interest rate is I the time is t, and the overall duration of the project is t*. Where At*, i is the annuity factor, which is equal to the sum of all discount factors throughout the project's duration. The EAC may be calculated by rewriting this equation:

$$EAC = \frac{NPV}{A_{t*i}} \tag{3}$$

$$A_{t*i} = \sum_{t=1}^{t^*} \frac{1}{(1+i)^t} = \frac{1-(1+i)^{-t*}}{i} \tag{4}$$

For the asset replacement type problem, there are mainly two cases:

One is that there are two asset options when replacing old assets, but due to the different life spans of these two assets, it is impossible to directly compare the options. For example, there are two options to replace the old equipment;

One is equipment A with a total cost of $2000 and a service life of 10 years; the other is equipment B with a total cost of $7000 and a service life of 5 years. At this time, it is impossible to directly compare $2000 and $7000.

The other is the replacement frequency of old assets. It is more appropriate to replace them every few years. For example, it can be replaced in 5 years or 8 years, but the total cost may be different due to the corresponding occurrence. Therefore, direct comparison is not possible at this time.

In fact, the essence of these two situations is due to the different years, and it is impossible to directly compare the cost. Therefore, the EAC (Equivalent Annual Cost method), which we will talk about next, will be used to calculate the comparison. This method not only solves the limitation of different years, that is, it is evenly switched to the present value of the cost of each year, so that in the same period (one year as the basis), the principle of whoever is selected will be selected. The time value of money is also considered. So the results will be more objective and accurate.

But this approach has several assumptions:

① No matter which option is chosen, it only affects the cost and has no impact on the cost and efficiency of operating activities.

② The project can be reset indefinitely. Once the replacement is completed, it will continue to be used, regardless of the next decision-making problem.

Then the calculation steps for such problems are as follows:

Step 1: Step 1: Determine the net present value of each replacement option's cost.

Step 2: Divide the net present value of the cost by the corresponding annuity discount factor to get the equivalent annual annuity cost.

Formula: EAC=PV of Cost / Annuity Factor

Analog about the benefits of different project cycles: if the NPV of two projects is different, the project cycle is also different. When making a comparison and selection, according to the same idea, adjust the two projects to the same time dimension, that is, switch to the annual equal annual revenue, and then can be compared.

At this point the formula is: Equivalent Annual Benefit (EAB)=NPV of Project/Annuity Factor.

3.3. Second Section

Whole-life cost is the total cost of owning an object over its whole life, from acquisition to disposal, as determined by financial analysis. The "life-cycle" cost includes procurement and implementation, design and construction costs, operating costs, maintenance, related finance costs, depreciation, and disposal costs.

Whole-life cost includes expenditures that are often disregarded, such as those associated with environmental and social impact aspects.

The annual cost of owning, operating, and maintaining an asset throughout its whole life is known as the equivalent annual cost (EAC), whereas the whole life cost is the overall cost of the asset over its entire life.

3.4. Second Section

The discount rate or cost of capital among each project must be calculated, which is a restriction of EAC, as it is with most financial planning. Unfortunately, prediction results can be erroneous, and variables might change during the course of a project or the life of an asset.

3.5. Second Section

Equivalent annual costs are the annual costs associated with ownership, maintenance, and operation of the asset. This is an important consideration when deciding on asset purchases and budgeting. One determines the corresponding annual cost in use by looking at the asset's baseline price and expected cost of maintenance and operation, and dividing by the asset's expected number of years. For example, an asset expected to be used for five years, costing $100,000 (USD) and operating at $2,000 per year would have an equivalent cost of $22,000 per year. This is calculated as people weigh their purchasing options. Knowing the equivalent annual cost of one asset is useful because it can help people with budgeting and decision-making, but it becomes especially important when choosing between multiple assets. For example, if an asset has a longer useful life, its annual equivalent cost may be lower. A company concerned with near-term costs may be attracted to a cheaper asset, however, we found that pricing compared to other assets suggests that such an asset will be more expensive in the long run. Companies producing assets that can be considered major purchases can often provide information on maintenance costs based on their experience and that of other customers. One can also ask a real estate agent about their expected annual maintenance costs, including taxes, insurance, and the cost of keeping the facility in good repair, for example, a company considering purchasing a new facility. The useful life of an asset is based on the performance of similar assets and the asset's designed to estimate. Experts can provide people with information on the expected useful life of an asset they are considering purchasing, and people can also consider factors such as product warranties. In addition, when estimating the average annual cost, one must also consider the possibility of business expansion and development, which requires early replacement of assets before the end of their useful life, which ordinary people can apply to their own lives, before purchasing a car, electrical appliances and other major commodities, the same annual cost should be considered. Next, let's learn about the application of the equivalent annual cost in real life and all walks of life (Table 2).

Table 2: The research and application of EAC.

THE RESEARCH AND APPLICATION OF EAC		
Author	Application field	conclusion
Scott L. Lummer	Evaluating Investment Alternatives with Unequal Lives Under	If prices are steadily growing, equivalent annual costs have little value. In the absence of inflation, their one-to-one relationship with the net present value of infinite replacement cycles (NPV*) ensures their validity. There is no correlation between EAC and NPV* if inflation happens. Despite the fact that one asset has a higher EAC than the other, it has a smaller NPV*. A numerical example in the appendix shows how employing EAC in an inflationary climate might result in poor conclusions. As a result, EAC analysis isn't a good tool for making decisions. This section's goal is to show that EAC's counterpart, equivalent real annual cost (ERAC), may be utilized as a legitimate selection criteria. It will achieve the same outcome as the replacement chain method, but with a lot less computing work [8].
M.A. (Maarten) Schoemaker&J.G. (Jules) Verlaan& R. (Robert) Vos & M. (Matthijs) Kok	The use of equivalent annual cost for cost-benefit analyses in flood risk reduction strategies	All (combinations of) measures in an item of annual spending are expressed in the equivalent annual cost. This assures that the EAC is a useful tool for comparing (combinations) of measures with varying economic lifespans. The use of the EAC approach appears to give a solid indication of where the most cost-effective flood risk reduction plan will go. This means it may be used to find nearly cost-effective flood risk mitigation options. This is now done manually, although it is possible to automate it. Every facet of flood risk reduction may be expressed in monetary terms, which is why similar yearly expenses are used. Other factors, such as the nature impacts of canalization, will play a role in practice where this is not possible [5].

Edyta Plebankiewicz, Krzysztof Zima1, and Damian Wieczorek [9]	Life Cycle Equivalent Annual Cost (EAC) as a Comparative Indicator in the Life Cycle Cost Analysis of Buildings with Different Lifetimes	A continuation of the authors' research work to construct a model for calculating the life cycle cost of a building, taking into account risk factors. The main purpose of the study is to propose a part of a model in which the life cycle cost of buildings with different lifespans is calculated using the Life Cycle Equivalent Annual Cost Indicator [4].
David R. Sinclair, MD [10]	comparing the cost of multi-use medical devices	The equivalent annual cost (EAC) of each pump should be calculated to account for these factors. The EAC is the annual cost of owning and operating the pump over its entire life. When assessing the yearly costs of multi-use devices with uneven service-lives and operating expenses, such as monitoring equipment or airway management systems, the EAC may be utilized as a decision-making tool in capital budgeting. The EAC is built on the foundation of the supposition that when a device approaches the end of its useful life, it will be replaced by a similar item indefinitely. The EAC does not take into consideration that the device will be used for a shorter duration than its service life or that it will be upgraded during that time [3].

4.CONCLUSIONS

The above are some of my research introductions about equivalent annual annuity（EAA） and equivalent annual cost（EAC）, focusing on the advantages of EAA and EAC, the derivation of the formula, the limitations and the application in real life. It is found that EAA and EAC can play a great role in the selection of investment projects with different lifespans and the comparison of investment projects, and through the method of searching literature, the research using EAA and EAC in recent years has been sorted out, which can be more intuitive and clearer. In fact, EAA and EAC are very useful in financing and other aspects. However, in the process of searching for information, it is found that there are still a lot of blanks in the current research on EAA and EAC, and there are few literatures, especially about EAA in real life and various industries. The research used in various industries is very vacant, I think we should study more about the application and limitations of EAA, so I hope this article can give some inspiration to people who are studying EAA and EAC, and hope that EAA and EAC can be better It is used to evaluate investment costs and investment returns.

REFERENCES

[1] Gallo (2014). A Refresher on Net Present Value. Harvard Business Review. cogencygroup.ca, 1–3.

[2] D. Han, H. Qi and A. Xie (2021). On the Equivalent Annual Cost Method. Journal of the Finance Issues: Vol. 19 No. 1, 54-63.

[3] D. R. Sinclair, MD (2010). Equivalent annual cost: a method for comparing the cost of multi-use medical devices. Canadian Anesthesiologists' Society.521–522

[4] E. Plebankiewicz, K. Zima, and D. Wieczorek (2018). Life Cycle Equivalent Annual Cost (EAC) as a Comparative Indicator in the Life Cycle Cost Analysis of Buildings with Different Lifetimes. MATEC Web of Conferences 196,1–8.

[5] H.A. Schoemaker, J.G. Verlaan, R. Vos, M. Kok (2016). The use of equivalent annual cost for cost-benefit analyses in flood risk reduction strategies. E3S Web of Conferences 7, 20005, 1–12.

[6] J. A. Paulo, M. ToméJj (2017). Using the SUBER model for assessing the impact of cork debarking rotation on equivalent annual annuity in Portuguese stands.26(1), e008, 1–11.

[7] S. Behringer (2015). The Development of the Net Present Value (NPV) Rule Religious Prohibitions and Its Evolution" Review of Economics & Finance Submitted on 11/12/2015 Article ID: 1923-7529-2016-03-74-14, 74-87

[8] S. L. Lummer (1986). Equivalent Real Annual Costs: Evaluating Investment Alternatives with Unequal Lives Under. THE ENGINEERING ECONOMIST, 31:4, 317-326

[9] X. Cui, Y. Li, X. Wang, Z. Wang (2022). Analysis of the Net Present Value and Equivalent Annual Cost in Optimal Machine Life. Proceedings of the 2022 7th International Conference on Financial Innovation and Economic Development