Selection of suitable economic analysis methods for the engineering education and research

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Abstract

Economic analysis in the engineering education and research is one of the necessary steps for the successful commitment of the engineering projects. However, there are so many different economic analysis methods that engineers are very confused which to choose and adapt for their own projects. For this problem, this paper will present all the present economic evaluation methods in practice with their meanings and characteristics, and will find out valuable methods for engineers by use of classification and analysis. So that this will lead engineers feel easy when they choose the suitable analysis method and help to the right economic decision for their engineering projects.

Keywords: Economic analysis methods, Classification, Right economic decision.

1. Introduction

Engineering is not a science. That means the engineering is different from the science. Science deals with and tries to explain the natural phenomena but engineering deals with technology that makes people happy, in other words, that creates the value. Science tries to solve 'the why' but engineering tries to make value through 'the how'. That's the difference. Engineering is an applied science and one of the purposes of engineering is the contribution to the profit of enterprise. That's why engineering is judged not only by the physical efficiency but also economic efficiency. In other words, engineering is not only a technology but also an economy.

Therefore, engineers should understand the value of the technology which they try to develop. The value can be counted by the comparison between the input and the output in the economic view. The main interest of investors, whatever company or government, is the profit from the technologies that engineers are developing. That's why engineers have to know how the economic analysis is performed and why engineering education should contain the subject of economic analysis.

But the problems of the engineering economic analysis for engineers are in the abundance and variety of analysis methods which are hard to understand and apply. That is, there are so many different types of economic analysis methods which sometimes make different conclusions that engineers are quite confused to decide which are correct and which alternative is to choose for their own purpose of engineering project. However, engineers do not need to understand all of the economic analysis methods because they do not need that much and it is not necessary to apply all the methods for right decision. Then, the problem is how to distinguish the essential methods or the needless methods from the pool of various analysis methods.

For this problem, this paper collects all the possible economic analysis methods around us and presents the meanings and characteristics of the each method. And then the methods are classified and analyzed by use of various criteria to choose suitable one for the engineering education and research. The results will make engineers feel comfortable in the choosing and studying the economic analysis methods to decide whether their engineering projects are valuable.

2. Collection of economic analysis methods

Economic analysis method can be defined as a technique which helps investors to decide the best economic alternative including zero alternative (doing nothing). Economic alternative means the alternative that makes bigger profits or advantages than the others. Therefore, the best economic alternative can be different according to the economic circumstance of projects. That's the one of the reason why so many economic analysis methods are present. Thus engineers have to recognize the reasons of existence of each method and should be able to grasp the actual meanings of each analysis method. To solve these problems, the definitions and characteristics of each economic analysis method are represented as follows.

(1) Net present value method (NPV)
Present value means the result of transforming the future value into present value by use of given discount rate. Therefore net present value means the monetary gap between the present value of life cycle revenues of a project and that of costs. The method judges as economic when net present value is bigger than 0.

(2) Net annual value method (NPA)
It is the same method as the net present value method except the annual value in substitution of present value. It is useful when annual values are compared.

(3) Internal rate of return method (IRR)
Rate of return means the rate of interest that makes the present value of life cycle revenues equals that of costs. So, internal rate of return represents the rate of interest that makes net present value of a project 0. Therefore when the rate of return of a project is bigger than the required marginal attractive rate return, the project is judged as being economic.

(4) Payback period method (PB)
Payback period means the time period when sum of the annual revenues gets over the amount of the initial investment. Thus when the payback period is shorter than the required time span, the project is judged as being economic. PB is a good indicator of fast capital recovery.

(5) Profitability index method (PI)
Profitability index means the ratio of sum of the present value of life cycle revenues divided by the sum of the present value of life cycle costs of a project. Thus, it is considered as economic when the profitability index is bigger than 1.

(6) Profitability index under constraints method (PIC)
It is similar to the profitability index method but the calculation is different. Here, the profitability index is calculated as a ratio of the sum of the present value of life cycle revenues divided by the initial amount of the investment. Also, it is considered as economic when the profitability index is bigger than 1.

(7) Benefit Cost analysis method (BC)
It is same as profitability index method. But here, present value of the revenues includes wide range of the benefits that occurred by the project such as public construction.

(8) Accounting rate of return method (ARR)
Accounting rate of return means the ratio of net annual average revenues after tax and depreciation divided by annual average value of properties invested for a project. The data of net revenues comes from the accounting P/L statement. It is considered as economic when the accounting rate of return is bigger than the required rate of return.

(9) Return on investment method (ROI)
Return on investment means the ratio of accounting net profit of that year divided by the total investment of the company. Therefore, it represents the production or financial performance of that year of a company, and it is considered as successful when the ROI index is bigger than the required rate of return.

(10) Economic value added method (EVA)

Economic value added means the amount of money made by a company of a year over the costs including tax and cost of capital. It is used as a management index that shows how much a company made profit over the invested capital.

(11) Break-even point method (BEP)

Break-even point means the amount of production of a year that make the revenue and the cost of a company same. Thus break-even point method can indicate how much production a company needs to make earnings and expenses even. So, the size of demand or order per year of that product can be a criterion of investment.

(12) Real options method (RO)

Real options method includes the concepts of future fluctuation of decision corresponding to the change of managerial circumstances of a company. It is usually applied in addition to the traditional decision analysis such as NPV. But it is hard to understand and sometimes subjective.

3. Classification of economic analysis methods

As mentioned above, there are so many economic analysis methods in practice that are not always useful. Thus we need to select some appropriate methods which are essential and convenient for the engineers to use. The analysis and the selection can be evolved by use of following 8 classification schemes as below.

Table 1. Classification by evaluation measure.

Evaluation measure	Analysis method
Amount of money	NPV, NPA, EVA, RO
Ratio of output/input	IRR, PI, PIC, BC, ARR, ROI
Time of capital recovery	PB
Amount of production	BEP

Table 2. Classification by decision basis.

Decision basis	Analysis method
0	NPV, NPA, EVA, RO
1	PI, PIC, BC
Required ratio	IRR, ARR, ROI
Required time	PB
Break even amount	BEP

Table 3. Classification by frequency used in Forbes 500 Co.

Use frequency	Analysis method
Above 50%	NPV, IRR, PB
Below 50%	ARR, PI, RO
Record not available	NPA, BC, PIC, ROI, EVA, BEP

Table 4. Classification by use of time value of money.

Time value of money	Analysis method
Adapted	NPV, NPA, IRR, PI, PIC, BC, BEP, RO
Not adapted	PB, ARR, ROI, EVA

Table 5. Classification by use of life cycle.

Life cycle time	Analysis method
Included	NPV, NPA, IRR, PI, PIC, BC, RO, BEP, PB, ARR
Not included	ROI, EVA

Table 6. Classification by target of evaluation.

Target of evaluation	Analysis method
Project	NPV, NPA, IRR, PI, PIC, BC, RO, BEP, PB, ARR
Company	ROI, EVA

Table 7. Classification by data used.

Data used	Analysis method
Cash flows of project	NPV, NPA, PB, IRR, PI, PIC, BC, RO
Accounting data of company	ARR, ROI, EVA, BEP

Table 8. Classification by ease of use.

Level of simplicity	Analysis method
Easy without interest	PB, ARR
Normal with interest	NPV, NPA, IRR, PI, PIC, BC, ROI, EVA, BEP
Complicated	RO

4. Discussion and conclusion

Technologies invented by engineers are not always useful or successful in the real world. That's not because of its poor physical efficiency but because of its lack of economical efficiency. However, engineers sometimes forget the importance of economic aspects in their R&D and projects. That's why engineering education should emphasize the concept of economic evaluation and the economic education to the engineers. But when you try to find and learn the economic evaluation method, you will realize that there are so many methods that make you complicated. Then how we will find necessary and easy methods for engineers who are not in major of economic analysis? That's the reason why this paper is written. For that problem, this paper collects most of the possible economic analysis methods that are used in economic evaluation. These collected 12 methods are classified and analyzed for the selection of suitable methods for engineers. Then, what should be the criteria of selection? Those may be easy to understand, simple to use, applicable to projects (not to company), popular to others, etc. Then, what are the right economic analysis methods in these criteria? According to the classifications and analyses in chapter 3, (Table 9) can be derived.

Table 9. Useful analysis methods in grade

Grade	Analysis method
Excellent	NPV, IRR, PB
Good	NPA, BC, PI
Fair	PIC, ARR, BEP
Poor	ROI, EVA, RO

The results indicate that the engineers are required to know the methods of NPV, IRR and PB for the economic analysis in addition to the concept of economic analysis, like time value of money and cash

flows (Table 3, 4, 5, 6, 7, 8). That means these are enough for engineers to make an economic decision for their own projects. Since ROI and EVA are made for the grade of a company's accomplishment (Table 6) and also are out of time value of money (Table 4), they are not recommended for a project evaluation. Also, RO is too complicated to use for engineers (Table 8). NPA, BC and PI are sometimes useful so that engineers are recommended to understand the concept of the method. But PIC, ARR, BEP are not considered useful so much (Table 4, 5, 6, 8).

As a conclusion, engineering education has to include at least the study for NPV, IRR, PB methods for economic analysis. That would help engineers enough to judge their R&D projects are useful or not before being started or continued.

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