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Masters in Civil Engineering

Project Cost-Benefit Analysis

Coursework Objectives:

Systematic evaluation of the economic and social benefits and costs of projects. Decision-making in an environment of limited resources, environmental and economic constraints, and uncertainty. The economy of multi-year projects, selection among competing independent alternatives, before and after tax analyses, replacement economy and inflation.

Contents

I- INTRODUCTION

A cost-benefit analysis is a systematic process that businesses use to analyze which decisions to make and which to forgo. The cost-benefit analyst sums the potential rewards expected from a situation or action and then subtracts the total costs associated with taking that action. Some consultants or analysts also build models to assign a dollar value on intangible items, such as the benefits and costs associated with living in a certain town.

KEY TAKEAWAYS

- A cost-benefit analysis is the process used to measure the benefits of a decision or taking action minus the costs associated with taking that action.
- A cost-benefit analysis involves measurable financial metrics such as revenue earned or costs saved as a result of the decision to pursue a project.
- A cost-benefit analysis can also include intangible benefits and costs or effects from a decision such as employees morale and customer satisfaction.
- More complex cost-benefit analysis may incorporate sensitivity analysis, discounting of cashflows, and what-if scenario analysis for multiple options.
- All else being equal, an analysis that results in more benefits than costs will generally be a favorable project for the company to undertake.

II- UNDERSTANDING

Before building a new plant or taking on a new project, prudent managers conduct a cost-benefit analysis to evaluate all the potential costs and revenues that a company might generate from the project. The outcome of the analysis will determine whether the project is financially feasible or if the company should pursue another project.

In many models, a cost-benefit analysis will also factor the opportunity cost into the decision-making process. Opportunity costs are alternative benefits that could have been realized when choosing one alternative over another. In other words, the opportunity cost is the forgone or missed opportunity as a result of a choice or decision.

Factoring in opportunity costs allows project managers to weigh the benefits from alternative courses of action and not merely the current path or choice being considered in the cost-benefit analysis. By considering all options and the potential missed opportunities, the cost-benefit analysis is more thorough and allows for better decision-making.

Finally, the results of the aggregate costs and benefits should be compared quantitatively to determine if the benefits outweigh the costs. If so, then the rational decision is to go forward with the project. If not, the business should review the project to see if it can make adjustments to either increase benefits or decrease costs to make the project viable. Otherwise, the company should likely avoid the project.

A- **Evaluation of the economic and social benefits and costs of projects.**

The first step in any economic evaluation is to project the cash flow. The cash flow of a project is the difference between the money generated (revenue) and ongoing costs (expenses) of the project. The definition of cash flow is different from accounting profit. The cash flow, for instance, ignores depreciation and the interest charges, since they are accounted for in other ways.

summarizes the main differences between the cash flow and the accounting profits.

Cash Flow Versus Accounting Profit

	Cash Flow	**Accounting Profit**
Revenues	When cash comes in	When sales occur
Operating expense	When cash goes out	When expenses occur
Depreciation	Not included	Included
Capital allowances	Tax shield included as cash flow	Included in tax accounts
Taxes	When tax is paid (one year time lag)	When tax is incurred

Cost-benefit analysis (CBA) comprises, not one, but a set of analytical tools used to assess the financial and economic viability of a proposed investment. Some of the analytical tools that can be used include:

- Benefit-Cost Ratio
- Net Present Value (or Discounted Cash Flow)
- Internal Rate of Return
- Least Cost Planning
- Payback Period
- Sensitivity Analysis

The BCR is calculated by dividing the proposed total cash benefit of a project by the proposed total cash cost of the project.

-Formula

$$IRR = r_a + \frac{NPV_a}{NPV_a - NPV_b}(r_b - r_a)$$

r_a = lower discount rate chosen
r_b = higher discount rate chosen
N_a = NPV at r_a
N_b = NPV at r_b

$$\underset{\text{Internal Rate of Return}}{IRR} = \underset{\text{Net Present Value}}{NPV} = \sum_{n=0}^{N} \frac{CF_n}{(1+IRR)^n} = 0$$

illustrations

in very simple format, how each of the various CBAs are calculated. The four-year project assumes a discount rate of 10%.

Sample Calculation of BCR, NPV, Discounted Cash Flow and IRR

Year	Cost	Benefit	Discount rate 10%	Discounted Cost	Discounted Benefit	Discounted Net Benefit	Discount Rate 23%	Disc.Net Benefit at 23%
0	100	0	1	100	0	-100	1	-100
1		30	0.909		27.3	27.3	0.813	24.5
2		40	0.826		33.1	33.1	0.661	26.7
3		50	0.751		37.6	37.6	0.537	26.9
4		50	0.683		34.2	34.2	0.437	21.8
				100	132.0	32.0		0.1

Benefit-Cost Ratio is Discounted Benefit/Discounted Cost or 132/100 = 1.32:1.0

Net Present Value is Discounted Benefit less Discounted Cost or 132 100 = $32

Discounted Cash Flow is the Discounted Net Benefit or $32

Internal Rate of Return is that Discount Rate when the Discounted Cash Flow = 0 which is 23%

Payback Period occurs early in year 3 when benefits begin to exceed $100.

B- DECISION-MAKING IN AN ENVIRONMENT OF LIMITED RESOURCES, ENVIRONMENTAL AND ECONOMIC CONSTRAINTS, AND UNCERTAINTY.

The kinds of decision made by people depending upon the available information.
Threre are three making decision enviroments.

- Decision making under certainty
- Decision making under uncertainty
- Decision making under risk

- **Decision making under certainty**

In this environment, decision makers know certainty, the consequenses of every alternative or decision choice. Certainty they will choose the alternative that will maximize their well-being or will result in best outcomes.

For example
If you have 1000 $ to invest a one year period.
- One alternative is to open a saving account paying 6% interest and
- Another is to invest in govement treasury bond paying 10ù interest.

  If both investments are secure and garanteed, there is certaainty that the treasury bond will pay higher return.
  The return after one year will be 100$ interest.

- **Decision making under risk**

In decision making under risk, there are several possible outcomes for each alternative and the decision maker knows the probability of occurrence of each outcomes.

For example

We know that the probability a 5 on die is 1/6 in decision making under risk,the decision maker usually attempts to maximize his or her expected well being.

The busness problems in this environment typically employ two equivalent criteria.
- Maximization of expected monetary value and
- Minimization of expected opportunity loss.

- C- Decision making under uncertainty

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In the decision making under uncertainty, there are several possible outcomes for each alternative, and the decision maker doesn't know the probabilities of the various outcomes.

For example
Somtimes, it's possible to asset the probability of a new undertaking or product.

The criteria for decision making under uncertainty are explained. Probabilities are not known.

In the decision making under uncertainty, we have five criterions :

1-Laplace criterion or equal probability or rationality probability or Bayes criterion

2- **criterion of optimision**
- Maximax criterion
- Minimin criterion

3-**criterion of pessimism**
- Maximin criterion
- MiniMax criterion

4-**minix regret criterion (savage criterion)**
-Maxinization problem
-minimization problem

5-**hurwicz criterion (criterion of realison)**
-Maxinization problem
-minimization problem

Example
1-Laplace criterion or equal probability or rationality probability or Bayes criterion
Formula : 1/n [P1+P2+P3…Pn]
This matrix gives the payoff of diffrent strategies(alternative) S1, S2, S3 and S4
Against conditions(events) N1, N2, N3 and N4

	N1	N2	N3	N4
S1	1000	1500	750	0
S2	250	2.000	3.750	3.000
S3	-500	1250	3.000	4750
S4	-1 .250	500	2.250	4.000

Expected payoff

S1	1 /4[1000+1500+750+0] = 812.50
S2	1 /4[250+2000+3750+3000] =2.250
S3	1 /4[-500+1250+3000+4750] =2.125
S4	1 /4 [-1 ,250+500+2250+4000]= 1.375

In the case of payoff, we selected the maximum value **S2=2.250**
In the case of matrix cost, we have to select the minimum value **S1=812.50**

2- **criterion of optimision**

- Maximax criterion

	N1	N2	N3	N4
S1	1000	1500	750	0
S2	250	2.000	3.750	3.000
S3	-500	1250	3.000	4750
S4	-1 .250	500	2.250	4.000

We choose the Maximun value

S1 = 1.500

S2= 3.750

S3= 4.750

S4=4.000

In this caseof maximax, we selected the maximum value **S4=4.000**

- **Minimin criterion**
- We choose the Minimum value S1 = 0 S2=250 S3= -500 S4=-1.250

- In this case of Minimini, we selected the minimum value **S4=-1.250**

3-**criterion of pessimism**

- Maximin criterion

First of all, we selected minimum value S1 = 0 S2=250 S3= -500 S4=-1.250

After that we choose the maximum value among minimun S2= 250

- MiniMax criterion

First of all, we selected Maximum value
S1 = 1.500 S2= 3.750 S3= 4.750 S4=4.000
After that we choose the minimum value among maximum S1=1.500

4-**minix regret criterion (savage criterion)**

a)Maxinization problem

	N1	N2	N3	N4
S1	1000	1500	750	0
S2	250	2.000	3.750	3.000
S3	-500	1250	3.000	4750
S4	-1 .250	500	2.250	4.000

Regret table					Maximun value
	N1	N2	N3	N4	
S1	0	500	3000	4750	4750
S2	750	0	0	1750	1750
S3	1500	750	750	0	**1500**
S4	2250	1500	1500	750	2250

Regret table= maxi payoff - payoff

The best alternative for implementation is **S3= 1500**

b) minimization problem

Regret table					Maximun value
	N1	N2	N3	N4	
S1	2250	1000	0	0	**2250**
S2	1500	1500	3000	3000	3000
S3	750	750	2250	4750	4750
S4	0	0	1500	4000	4000

Rgret table= cost –mini cost

MiniMax criterion

The best alternative is S1=2250

5-**hurwicz criterion (criterion of realison)**

a) **Maxinization problem**
payoff matrx

	N1	N2	N3	N4
S1	1000	1500	750	0
S2	250	2.000	3.750	3.000
S3	-500	1250	3.000	4750
S4	-1 .250	500	2.250	4.000

Apha α = 0.6

Weight of outcomes
WO =**Amax+(1-0.6).min**
S1=(0.6*1500)+(1-0.6).0= 900
S2=(0.6*3750)+(1-0.6).250= 2350
S3=(0.6*4750)+(0.4*-500)= 2650
S4=(0.6*4000)+(0.4*-1250)=190

maxi	mini	Weight of outcome
1500	0	900
3750	250	2350
4750	-500	2650
2250	-1250	1900

The best alternative to select is **S3=2650**

b)**minimization problem**

if Apha α isn't done ,we can assume between 0 to 1
Apha α = 0.5

Weight of outcomes
WO = **Apha α min+(1-0.6).max**

S1=(0.5*0)+(1-0.5).1500= 750
S2=(0.5*250)+(0.5*3750)= 2000
S3=(0.5*-500)+(0.5*4750)= 2125
S4=(0.5*1250)+(0.5*4000)=1375

mini	max	Weight of outcome
0	1500	750
250	3750	2000
-500	4750	2125
-1250	4000	1375

The best alternative is **S4=750**

c- Alternative

OBJE TIVE :
How to apply probability measures to select the best alternative out of mutually exclusive alternative.
Exclusive alternative.
The selection of one alternative excludes the consideration of any other alternative.

For example
If someone is shopping for used automobile, he considers several cars.but he will only buy one from a mutually exclusive set of choices.
1-Alternative being considered may require different amounts of capital investment.
2-the alternative may have different useful lives.

The subject of the topic
1-Analysis and compare feasable alternative
2-select the preferred alternative.
The cash flow analysis Methods used in this process
1-Present worh(PW)
2-Annual Woth (AW)
3-Future Woth (FW)
4-Internal rate of return
5- External rate of return
6-payback period

The alternative that require the **minimum investment** and produces **satisfactory** function result will be chosen unless.the incremental capital associated with alternative having a large investment can be justified with respect to its incremental savings (or benefits).

The alternative requiring the least or minimum investment is **base alternative.**
The rule ensures that as much capital as possible is investment at a rate of return equal to or greater than th MARR .
This implies to obtain at least the MARR for everydollar invested

Investment vs cost alternative

Investment alternative	Cost alternative
Project which revenues depend on the choise of alternative. Resume and cost streams vary with the choice of alternative.	Project wich revenues do not depend on choice of alternative. Fixed (or constant)revenues for all alternative.

Alternative are compared according to two main types of project problems.
1-investment alternative
Each alternative has an initial investment producing positive cash flow resulting from increasedr evenues reduced cost or both.

Do nothing is usually an implicit investment alternative.

2-cost alternative
Have all negative cash flows except for salvage value (if applicable) these alternatives represent must do situations and DN is not an option.

Include any economic impact of alternative difference in estimatedcash flows.
Two Roules
Roule1 :
When revunues and other economic benefit are present, select alternative that has greatest positive equivalent worth at i= MARR and satisfies project requiments.
Roule 2 :

When revunues and other economic benefit are not present or constant among alternatives, select alternative that minimizes cost (teast negative value) and satisfies project requiments.

Example

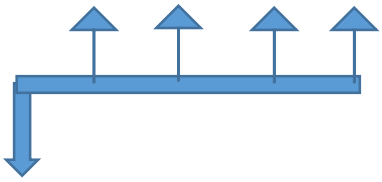
	alternatives	
	A	B
Capital investment	$60,000	$73,000
Annual revenus less expenses	22,000	26,225

MARR=10% , N=4

PWa= -$60,000+$22,000(P/A,10%,4)=$9,738
PWb=-$73,000+$26,000(P/A,10%,4)=$10,131

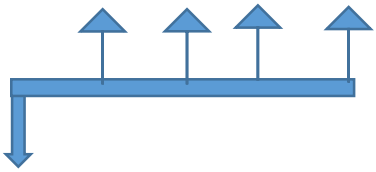
A is the base alternative (having tehe least capital) and is elected unless an additional capital is justified.
Since PWb > PWa , the additional capital of 13,000 is justified and B is selected

Alternative A
22,000



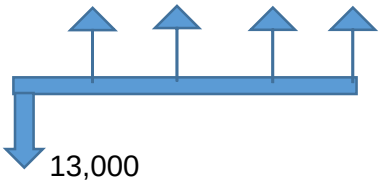
$60,000

Alternative B
26,225



$73,000

Alternative A minus Alternative B (year-by-year)
4,225



13,000

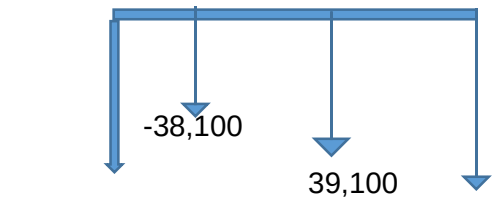
PW(10%)diff=-$13,000+4,225(P/A,10%,4)=$393,

Implementing roules 2 : cost alternative.

	Alternative	
End of year	**C**	**D**
0	-$380,000	-$415,000
1	-38,100	-27,000
2	-39,100	-27,000
3	-40,100	-27,000
4	0	26,000

Alternative C

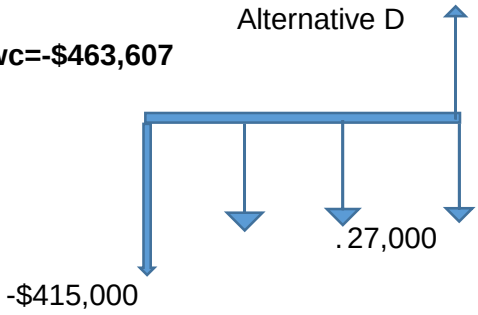
Pwc=-$477,077



26,000

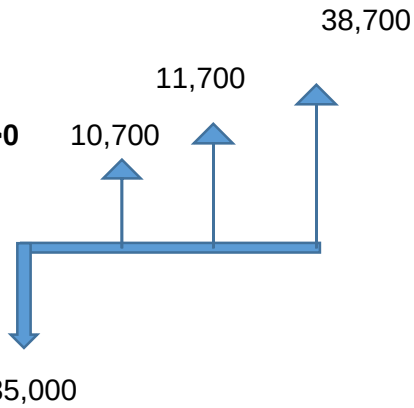
Alternative D

Pwc=-$463,607



Alternative C minus Alternative D **(year-by-year)**

Pwdiff= $13,470>0



We prefer D aver C

The study period is the selected time period over wich mutually exclusive alternatives are compared.as also known as planning horizontal.
The study peried may be influenced by factors including :

- Service period required
- Useful Life of the shorter-lived alternative
- Useful Life of the longer lived alternative
- Company polyce

It’s importante that The study period be appropriate for the decision situation under investigation.

Useful life : the period of time during wich an assept kept in producing operation.

Two situations :
Case 1 useful lives are the same for all alternatives and equal to the study period.
Case 2 useful lives are different among the alternatives, and at least one doesn’t match the study period.

Fundamental principle : compare mutually exclusive alternatives over the same period of time.

D- Before and after tax analyses

Economic analysis taking income taxes into account Income Taxes

Economic analysis taking income taxes into account

To fully evaluate an economic analysis taxes must be taken into account. The real value of an investment is strongly affected by the cost of taxes. As stated the principal elements in an after-tax analysis are :

- Before-tax cash flow (BTCF)
- Depreciation
- Taxable income (TI = BTCF – Depreciation)
- Income Taxes (TI * Incremental tax rate)
- After-tax Cash Flow (ATCF = BTCF – Income taxes)

- Before-tax cash flow
- The amount of money generated by an investment after collection of all revenues and payment of all bills, but without any deductions for depreciation or other noncash items, and before calculation of income tax consequences. An important figure in analyzing any investment,
  because properties with high depreciation expenses may show tax losses but positive cash flows.In the alternative,a property that requires expensive financing for acquisition or operation may show good net income figures for accounting and tax purposes, but have a negative cash flow requiring the owner to supplement the property with money from other sources.

- After-Tax Cash Flow (ATCF)
- Where, Depreciation, Depletion, Amortization, and Write-offs are called Non-cash capital cost deductions. ATCF can be written in form of equation as:
  - After-Tax Cash Flow=Net Income+Non-Cash deductions–Capital costAfter-Tax Cash Flow=Net Income+Non-Cash deductions–Capital cost
- **Equation 1**
- Or
  - After-Tax Cash Flow=Sale Revenue–Operating Costs–Income Taxes–Capital CostsAfter-Tax Cash Flow=Sale Revenue–Operating Costs–Income Taxes–Capital Costs
- **Equation 2**
- As explained in Example 7-2 and 7-3, depending on the characteristics of investment, Before-Tax Cash Flow and After-Tax Cash Flow calculations might be different and may give different economic results.

For example

A medium- sized profitable corporation may be a $15000 used pickup truck for use by the shipping and receiving department. During the truck's 5-year useful life, it's estimated the firm will save $4000 per year after all the cost of owning and operating the truck have been paid.

Truck salvage value is estimated at $4500.so that this can be solved using an equation or annuity function rather than a full spreadsheet, assume that straight-line deprciation is used.

a- What is the before tax rate of return ?
b- What is the after tax rate of return on this capital expediture ?
Assume strait –line depreciation

year	**Before tax cash flow**	**depreciation**	**Taxable income**	**Income taxe**	After tax cash flow
0	**-15k**				**-15k**
2	**4k**	**2100**	**1900**	**646**	**3354**
3	**4k**	**2100**	**1900**	**646**	**3354**
4	**4k**	**2100**	**1900**	**646**	**3354**
5	**4k** **4,5k**	**2100**	**1900**	**646**	**3354**

After cash flow

To construct the after cash flow tabla, follow these steps
1-Before-tax cash flow
2-calculate depreciation (SLN, DDB, MACRS)
3-calculate taxable income (Before – tax cash flow - Depreciation)
4-calculate income taxes (taxable income*incremental tax rate)
5-after cash flow (Before cash flow (Before-tax cash flow-income taxes)

E-REPLACEMENT

Introduction :

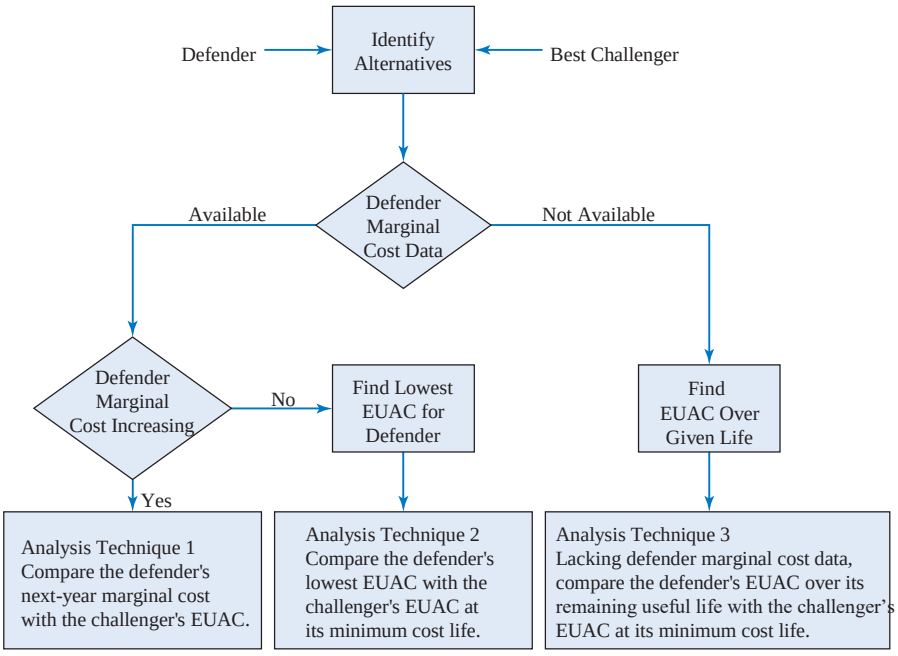
Should existing equipment be retainned or replaced ?
Defender is the existing equipment
Chanllenger is the best available replacement equipment

If defender proves more economical, it will be retained
If the **challenger** proves more economical, it will be retained
Economically evaluating the existing defender and its challenger is domain of Replacement analysis

REPLACEMENT PROBLEM

Replacement of an existing asset may be appropriate due to **obsolescence, depletion**, and **deterioration** due to aging. In each of these cases, the ability of a previously implemented business asset to produce a desired output is challenged. For cases of obsolescence, depletion, and aging, it may be economical to replace the existing asset. We define each of these situations.

REPLACEMENT ANALYSIS MAP DECISION.



Choosing a single challenger

-when considering replacement ,we may have many challenger, but our analysis techniques require us to choose just one.

How do we do that

NPW ,EUAC,IRR,B/C but the important point is that each challenger must be avaluated at its minimum cost life.

MINIMUM COST LIFE.

-an assets could have several possible lives depending on when that assets minimum cost life.

Example

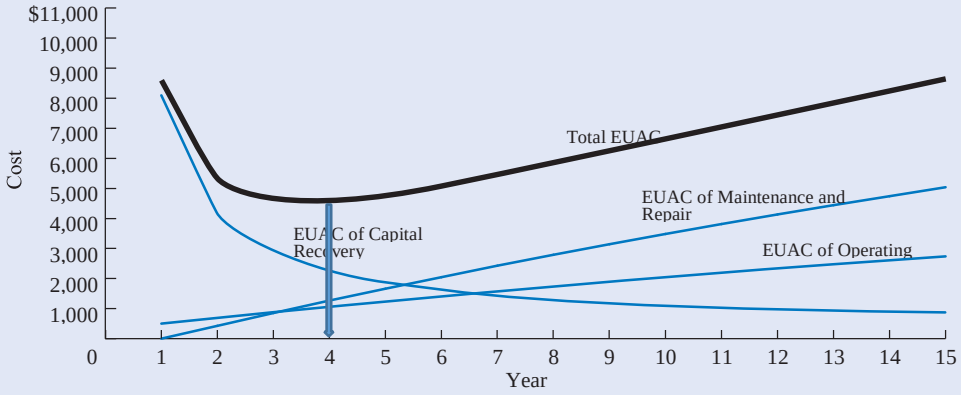
A peace of machinery cost $ 7,500 and has no salvage value after it is installed.

Second year maintenance cost $900 and this iterm will increase on a $900 arithmetic gradient in subsequent years.

First year : operating expenses for machinery will be $500 and will increase on a $400 arithmetic gradient in the following years.

-if interest is 8%,, compute machinery's economic life that minimizes the EUAC.that is find its minimum cost life.

Year	EUAC of capital recovery costs $7500(A/P ,8%,n)	Maintenance and repair costs $900(A/G,8%,n)	EUAC of operating cost $500+$400(A/G,8%,n)	EUAC(total)
1	8100	0	500	8600
2	4206	433	692	5331
3	2910	854	880	4644
4	2264	1264	1062	**4590**
5	1878	1661	1238	4779
6	1622	2048	1410	5082
7	1441	2425	1578	5442
8	1305	2789	1740	5833
9	1201	3142	1896	6239
10	1118	3484	2048	6650
11	1051	3816	2196	7062
12	995	4136	2338	7470
13	949	4446	2476	7871
14	910	4746	2609	8265
15	876	5035	2738	8649



The minimum cost life = 4 years

F- INFLATION AND PRICE CHANGE

INFLATION : is the rate at which the value of a currency is falling

DEFLATION : opposite of inflation ; purchasing power of money is greater in future than at present.

Rates :

Real rate i –rate at which interest is earned when effect of inflation are removed ; represents the real increase in purchasing power.

Market or inflation-adjusted rate if- rate that takes inflation into account. Commonly stated rate everyday.

Inflation rate f – rate of change in value of currency.

P=F/(1+F) ᴺ(1+i) ᴺ

=f=1 /(1+i+f+ i f)

If the term i+f+i f defined as if,the equation becomes

P=F/(1+F) ᴺ= F(P/F ,i,n)

The inflation-adjusted interest rate **if** is defined as

If=i+f+if

Example

Money in a medium-risk investment guaranteed 8% per year. Inflation rate has averaged 5,5% per year. What is the real rate of return on investment ?

If=i+f+if

I=if-f /1+f

I=(0.08-0.055) /(1+0.055)=2.4%

I=2,4%

Constants value dollars

Using a dollars as currency, dollars in perid t1 are called constant value dollars or today's dollars .dollars in period t2 are called futur dollars or then current dollars and have inflation take into account.if f represents the inflation rate per period(year) and n is the number of times periods(year) between t1 and t2

Constant value dollars= futur dollars $/(1+f)^n$

Futur dollars=constant-value dollars$(1+f)^n$

PW calculation with inflation

1- Convert cash flow into constant value dollars and use regular i

Wher CV =futur dollars $/(1+f)^n$= then current dollars $/(1+f)^n$

(Note : calculation up to now have assumed constant-value dollars)

Express cash flow in futur(then current)dollars and use inflated interest rate

Where **i f =1+i+f+ (i)(f)**

Inflated interest rate is the market interest rate

Example

A machine will have a cost of $25000(futur cost)six year from now.find the PW of machine if the real interest rata is 10% per yearand inflation rate is 5% per year using (a) constent value dollars, and (b) futur dollars.

Solution

a) Determine constant value dollars and use i in PW equation

CV+ $25000(1+0.05)^6$=$18,655

PW=18.655(P /f ,10%,6)=$10,530

b) Leave as futur dollars and use if in PW equation

If =0.10+0.05 + (0.10)(0.05)=15,5%

PW=25000(P/f,15.5%,6)=$10,530

Capitatal recovery with inflation

Example

A company invest $150,000 in new production line machine ,how much must receive each year to recover the investment in 5 years ? the real interest rate is 10% and inflamation rate is 4 %per year.

Solution

Capital recover is the AW value

If= 0,10+0,05 +(0.10)(0,05)= 14,4%

CR= AW= 150,000(A/P,14.4%,5)=$44,115 per year

conclusion

- The traditional foundation for cost-benefit analysis (CBA) is traditional welfare economics, which offers a utilitarian theory of value that focuses on personal self-interest. In reality, preferences for a considerably broader range of societal objectives are expressed. Rarely do methods like CBA properly account for these broader public preferences. It is important to take into account how the public good is currently seen and how it might be effectively served.
- Even if certain costs and benefits are later eliminated, it is crucial to start a CBA with a complete inventory of every possible cost and benefit. Otherwise, crucial elements of the analysis can be missed.
- • Costs, benefits, and risks are rarely known with absolute confidence, especially whe n looking ahead.
  Due to this, it is crucial to perform a sensitivity analysis to see how resistant the CBA result is to changes in some of the critical numbers.

This course of economic analysis allowed me to understand the decisions to learn in the face of the multiple problems that can be faced in the world of economic business. There are several formulas that have not been detailed due to the number of pages.