Investment Appraisal

Lirong Liu
lirong.liu@surrey.ac.uk
www.surrey.ac.uk/ces

Outline

1 Introduction

2 Method

- Simple Payback
- Discounted Cash Flow Analysis

3 Application

- Energy sector case studies
- Operation in Excel

1 Introduction

Appraisal

A type of decision method applied to a project, programme or policy that takes into account a wide range of costs and benefits.

Appraisal can be undertaken from different perspectives, depending on the objectives of the commissioning body.

- Environmental
- Economic
- Social

1 Introduction

Economic Appraisal

Economic appraisal is basically a way of comparing the expected costs of a project with its projected benefits.

It can be used to rank alternative projects as well as evaluating the “value” of one particular project.

- Is this investment profitable?
  Benefits (B) > Costs (C) or Net Benefits (NB) B -C > 0
- Are project options competing with one another?
  Net Benefits (NB) of project i > Net Benefits (NB) of project j

1 Introduction

Economic Appraisal

In principle, both the costs and the benefits of the project may be quite broadly defined and included.

- environmental costs, social benefits…

1 Introduction

Different Terminologies

Financial appraisal: a narrower concept, assessing the financial viability of an investment.

Economic appraisal: broader concept, could include non-financial aspects, such as the non-monetised ‘externalities’ of a project

Sustainable development demands that project appraisal methodologies take a broad view of economic, technical, environmental and social viability

1 Introduction

Economic Appraisal

In principle, both the costs and the benefits of the project may be quite broadly defined and included.

In practice, economic appraisal tends to be restricted to costs and benefits which can be defined in monetary terms.

Complexities:

- Analysis boundary
- Quantification in monetary term
- Temporal nature of cash flows

1 Introduction

Economic Appraisal

Economic appraisal of all investments is of vital importance to the sustainability of local communities

- Micro-financial concerns are vitally important to ordinary people, in particular those with lower incomes
- Development requires capital investment, and investors will want to know how effective their capital expenditure
- Intended beneficiaries of investments will also want to know the financial viability and long-term impacts

1 Introduction

Economic Appraisal

The value of the approach is as much in helping you understand the nature of the decision as it is in producing an answer:

–“It is best to think of the cost-benefit approach as a way of organizing thought rather than as a substitute for it.” —Michael Drummond

2 Method – Simple Payback

Simple Payback Time

The simple payback time is the period, usually expressed in years, within which the initial investment is completely recovered.

$$P = CC/(b-c)$$

Where

- P is the simple payback time
- CC is the total capital cost
- b is the projected annual benefits
- c is the projected annual running costs

2 Method – Simple Payback

Simple Payback Time

Feasibility requirement

$$P \leq n$$

Where

- P is the simple payback time
- n is the lifetime of the project

2 Method – Simple Payback

Simple Payback Time

An example of an investment in gas-fired electricity generation

$$P = CC/(b-c)$$

$P1 = ?$

Where

- P is the simple payback time
- CC is the total capital cost → 250
- b is the projected annual benefits → 100
- c is the projected annual running costs → 50

Unit: $1000

2 Method – Simple Payback

Simple Payback Time

An example of an investment in gas-fired electricity generation

$$P = CC/(b-c) \qquad P1 = 250/(100-50) = 5$$

Where

- P is the simple payback time
- CC is the total capital cost
- b is the projected annual benefits
- c is the projected annual running costs

→

Unit: $1000
250
100
50

2 Method – Simple Payback

Simple Payback Time

An example of an investment in gas-fired electricity generation

$$P = CC/(b-c) \qquad P1 = 250/(100-50) = 5$$

- If the lifetime of the gas-fired electricity generation is 6 years:
- If the lifetime of the gas-fired electricity generation is 4 years:

2 Method – Simple Payback

Simple Payback Time

An example of an investment in gas-fired electricity generation

$$P = CC/(b-c) \qquad P1 = 250/(100-50) = 5$$

- If the lifetime of the gas-fired electricity generation is 6 years:

  Feasible

- If the lifetime of the gas-fired electricity generation is 4 years:

2 Method – Simple Payback

Simple Payback Time

An example of an investment in gas-fired electricity generation

$$P = CC/(b-c) \qquad P1 = 250/(100-50) = 5$$

- If the lifetime of the gas-fired electricity generation is 6 years:
  Feasible
- If the lifetime of the gas-fired electricity generation is 4 years:
  NOT feasible

2 Method – Discounted Cash Flow Analysis

Discounted Cash Flow (DCF)

DCF analysis is a valuation method used to estimate the value of an investment based on its expected future cash flows.

It relies heavily on the principle of *discounting* future costs and benefits so as to represent them in terms of their present value.

2 Method – Discounted Cash Flow Analysis

Discounting

Discounting is a reduction in the perceived value now of a benefit or cost that is to be obtained / incurred in the future.

The value of having a given sum of money at a future date is less than the value of having the same sum of money today

- Time preference
- Time value

2 Method – Discounted Cash Flow Analysis

Discounting

- Time preference

Would you prefer to be given a bar of chocolate today, or be given a similar bar in a year's time?

If today, this is a simple expression of a time preference (your own impatience; expectation of increasing wealth over time; view of risk of dying)

2 Method – Discounted Cash Flow Analysis

Discounting

- Time value

Is £1 now the same as £1 in one year's time?

Investment:

- invest the £1 now at 5% interest rate, so it becomes £1.05 next year
- £1 given to you next year is equivalent to £1/1.05 = 95.2p given to you now

Inflation:

- Price of white sliced loaf of bread: 49p in 1989 VS £1.09 in 2019
- UK inflation rate is forecasted to be 1.8%-2% during 2022-2025

2 Method – Discounted Cash Flow Analysis

Discounting

Discounting is a reduction in the perceived value now of a benefit or cost, the further in the future it is to be obtained / incurred.

The value of having a given sum of money at a future date is less than the value of having the same sum of money today

- Time preference
- Time value

Discount rate (r) to discount future cash flows back to their present value

- ➢ 0 and 15-20%

2 Method – Discounted Cash Flow Analysis

Discounting

$$PV(X, r, t) = \frac{X}{(1+r)^t}$$

Where

- PV is the present value
- X is the future cash flow
- r is the discount rate
- t is the occurring year

2 Method – Discounted Cash Flow Analysis

Discounting

$$PV(X, r, t) = \frac{X}{(1+r)^t}$$

When r = 5%:

Where

- PV is the present value
- X is the future cash flow
- r is the discount rate
- t is the occurring year

2 Method – Discounted Cash Flow Analysis

Discounting

$$PV(X, r, t) = \frac{X}{(1+r)^t}$$

When r = 5%: $PV1 = \frac{105}{(1+5\%)^1} = 100$

Where

- PV is the present value
- X is the future cash flow
- r is the discount rate
- t is the occurring year

2 Method – Discounted Cash Flow Analysis

Discounting

$$PV(X, r, t) = \frac{X}{(1+r)^t}$$

When r = 5%: $PV1 = \frac{105}{(1+5\%)^1} = 100$

When r = 10%: $PV1 = \frac{105}{(1+10\%)^1} = 95.45$

Where

- PV is the present value
- X is the future cash flow
- r is the discount rate
- t is the occurring year

2 Method – Discounted Cash Flow Analysis

Discounting

$$PV(X, r, t) = \frac{X}{(1+r)^t}$$

Where

- PV is the present value
- X is the future cash flow
- r is the discount rate
- t is the occurring year

When r = 5%: $$PV1 = \frac{105}{(1+5\%)^2} = 95.23$$

When r = 10%: $$PV1 = \frac{105}{(1+10\%)^2} = 86.78$$

2 Method – Discounted Cash Flow Analysis

Choice of the discount rate

Public sector

- Determined according to an assumed social rate of time preference, or the rate of return on long-term government bonds
- UK Treasury’s stated rate (now 3.5%), reflecting the “Social Discount Rate”,: a reflection of a society's relative valuation on today's well-being versus well-being in the future

Commercial investors

- Based on the marginal rate of interest on capital
- At least equal to historic return on capital invested
- In practice, most investors will look at their own ‘cost of capital’

2 Method – Discounted Cash Flow Analysis

Choice of the discount rate

The capital funding of a company is made up of two components: debt and equity. The “cost of capital” is the expected return to equity owners and to debt holders.

Weighted Average Cost of Capital (WACC) is the firm’s overall cost of capital, weighting each capital source by its proportion in the firm's overall capital.

If 70% equity (and shareholders expect average return of 7%) and 30% debt (with average interest of 9%)

$$\text{WACC} = (0.7 \times 7\%) + (0.3 \times 9\%) = 7.6\%$$

2 Method – Discounted Cash Flow Analysis

Choice of the discount rate

One of the factors which is liable to affect the discount rate applied to a particular project is the degree of financial risk associated with the project.

Risk-adjusted discount rate = Risk free rate + Risk premium

The variation of risk premium is depending on the risk aversion of investor and the perception of investor about the size of property’s investment risk.

2 Method – Discounted Cash Flow Analysis

Discounted Cash Flow (DCF)

DCF analysis is a valuation method used to estimate the value of an investment based on its expected future cash flows.

- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Discounted Payback Period (DPR)

2 Method – Discounted Cash Flow Analysis

Net Present Value (NPV)

NPV is defined as the sum of the present values of all the costs and benefits incurred by the project.

$$NPV(X,r) = \sum_{t=0}^{N} \frac{(B_t - C_t)}{(1+r)^t}$$

Where

- NPV is the net present value
- B_t is the benefits in the year t
- C_t is the costs in the year t
- r is the discount rate
- t is the occurring year
- N is the project lifetime

2 Method – Discounted Cash Flow Analysis

Net Present Value (NPV)

Feasibility requirement

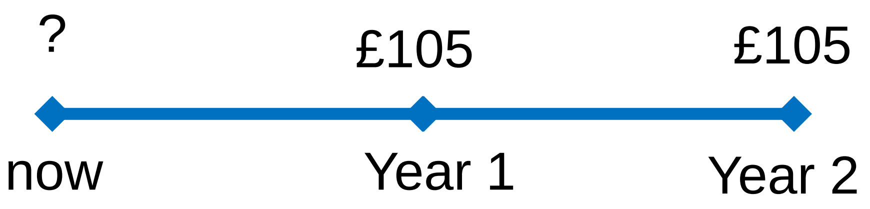
$$NPV \geq 0$$

Where

- NPV is the net present value

2 Method – Discounted Cash Flow Analysis

Net Present Value (NPV)



$$NPV(X, r) = \sum_{t=0}^{N} \frac{(B_t - C_t)}{(1+r)^t}$$

r = 5%: $$NPV = \frac{105}{(1+5\%)^1} + \frac{105}{(1+5\%)^2}$$

$= 100 + 95.23$

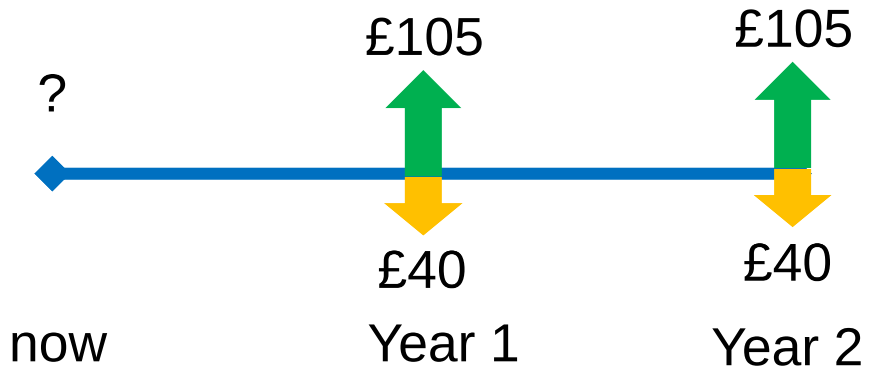
$= 195.23$

Where

- NPV is the net present value
- Bt is the benefits in the year t
- Ct is the costs in the year t
- r is the discount rate
- t is the occurring year
- N is the project lifetime

2 Method – Discounted Cash Flow Analysis

Net Present Value (NPV)



$$NPV(X,r) = \sum_{t=0}^{N} \frac{(B_t - C_t)}{(1+r)^t}$$

Where

- NPV is the net present value
- Bt is the benefits in the year t
- Ct is the costs in the year t
- r is the discount rate
- t is the occurring year
- N is the project lifetime

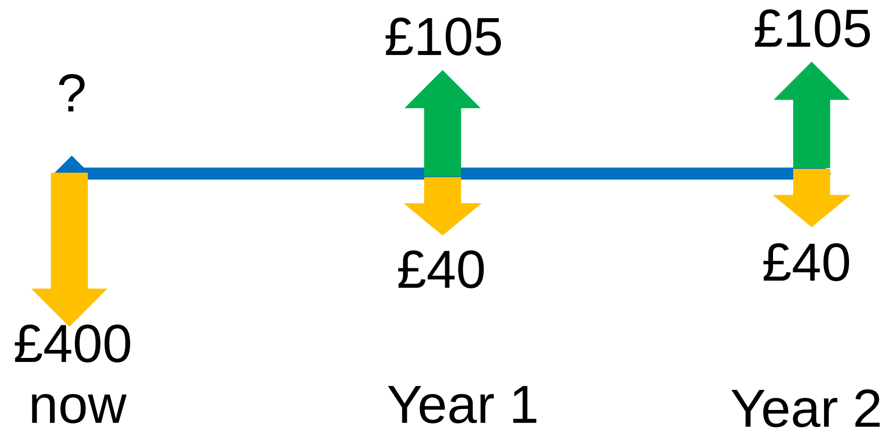
r = 5%: $$NPV = \frac{(105-40)}{(1+5\%)^1} + \frac{(105-40)}{(1+5\%)^2}$$

= 61.9 + 58.96

= 120.86

2 Method – Discounted Cash Flow Analysis

Net Present Value (NPV)



$$NPV(X,r) = \sum_{t=0}^{N} \frac{(B_t - C_t)}{(1+r)^t}$$

Where

- NPV is the net present value
- Bt is the benefits in the year t
- Ct is the costs in the year t
- r is the discount rate
- t is the occurring year
- N is the project lifetime

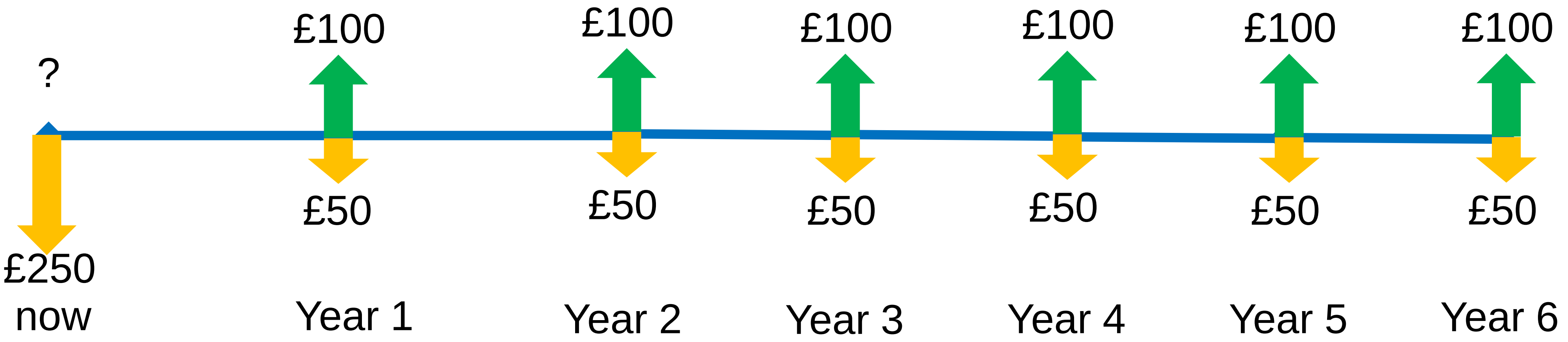
r = 5%: $NPV = \frac{-400}{(1+5\%)^0} + \frac{(105-40)}{(1+5\%)^1} + \frac{(105-40)}{(1+5\%)^2}$

= -400 + 61.9 + 58.96

= -279.14 NOT feasible

2 Method – Discounted Cash Flow Analysis

Example: gas-fired electricity generation



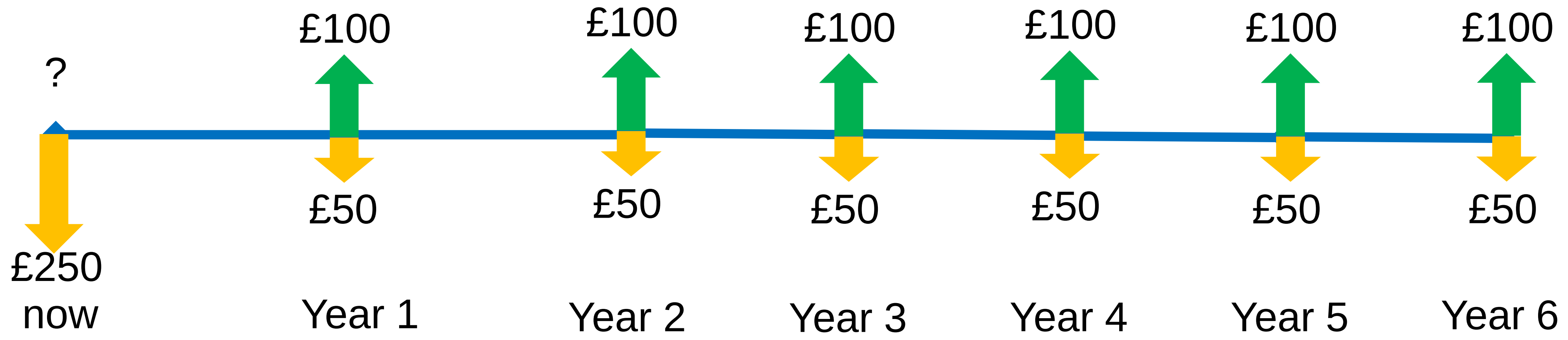
r = 5%: $$NPV = -250 + \frac{(100-50)}{(1+5\%)^1} + \frac{(100-50)}{(1+5\%)^2} + \frac{(100-50)}{(1+5\%)^3} + \frac{(100-50)}{(1+5\%)^4} + \frac{(100-50)}{(1+5\%)^5} + \frac{(100-50)}{(1+5\%)^6}$$

$$= -250 + 47.6 + 45.4 + 43.2 + 41.1 + 39.2 + 37.3$$

$$= 3.8$$ Feasible

2 Method – Discounted Cash Flow Analysis

Example: gas-fired electricity generation



r = 10%: $$NPV = -250 + \frac{(100-50)}{(1+10\%)^1} + \frac{(100-50)}{(1+10\%)^2} + \frac{(100-50)}{(1+10\%)^3} + \frac{(100-50)}{(1+10\%)^4} + \frac{(100-50)}{(1+10\%)^5} + \frac{(100-50)}{(1+10\%)^6}$$

$$= -250 + 45.5 + 41.3 + 37.6 + 34.2 + 31.0 + 28.2$$

$$= -32.2$$

NOT feasible

2 Method – Discounted Cash Flow Analysis

Internal Rate of Return (IRR)

IRR is defined as the discount rate r at which net present value equals to 0.

- Trial and error

2 Method – Discounted Cash Flow Analysis

Trial and error

Example: gas-fired electricity generation

Step 1: r = 5%: NPV>0   r = 10%: NPV< 0

5% < IRR < 10%

Step 2: r = 7%: NPV = -11.67

5% < IRR < 7%

Step 3: r = 6%: NPV = -4.13

5% < IRR < 6%

Step 4: r = 5.5%: NPV = -0.22

5% < IRR < 5.5%

Step 5: r = 5.2%: NPV = 2.17

5.2% < IRR < 5.5%

Step 6: r = 5.4%: NPV = 0.57

5.4% < IRR < 5.5%

Step 7: r = 5.45%: NPV = 0.17

5.45% < IRR < 5.5%

…

2 Method – Discounted Cash Flow Analysis

Internal Rate of Return (IRR)

IRR is defined as the discount rate r at which net present value equals to 0.

- Trial and error

Feasibility requirement:

$$\text{IRR} \geq \text{base interest rate}$$

2 Method – Discounted Cash Flow Analysis

Trial and error

Example: gas-fired electricity generation

Step 1: r = 5%: NPV>0   r = 10%: NPV< 0

5% < IRR < 10%

Step 2: r = 7

If the base interest rate is 6%, NOT feasible

If the base interest rate is 4%, Feasible

Step 3: r = 6%: NPV = -4.13

5% < IRR < 6%

Step 4: r = 5.5%: NPV = -0.22

5% < IRR < 5.5%

Step 5: r = 5.2%: NPV = 2.17

5.2% < IRR < 5.5%

Step 7: r = 5.45%: NPV = 0.17

5.45% < IRR < 5.5%

…

3 Application – Energy Sector Case Studies

Comparative Analysis

Example: gas-fired VS solar electric power generation

	Capital Cost	Annual Revenue	Annual Cost
Gas-fired	250	100	50
Solar	500	100	5

Unit: $

3 Application – Energy Sector Case Studies

Sensitivity analysis

To investigate the issues of risk, the sensitivity of the outcome to the assumptions made can be tested and illustrated in a number of ways

In the NPV methodology, one key parameter is the discount rate assumed for the project

Discount rate: 0%, 5%, 10%, 15%, 20%, 25%, 30%

3 Application – Energy Sector Case Studies

Functions in Excel

NPV function: Calculates the net present value of an investment by using a discount rate and a series of future payments (negative values) and income (positive values).

=NPV(discount rate, value 1:value n)+value 0

(future cash flow) (capital cost in year 0)

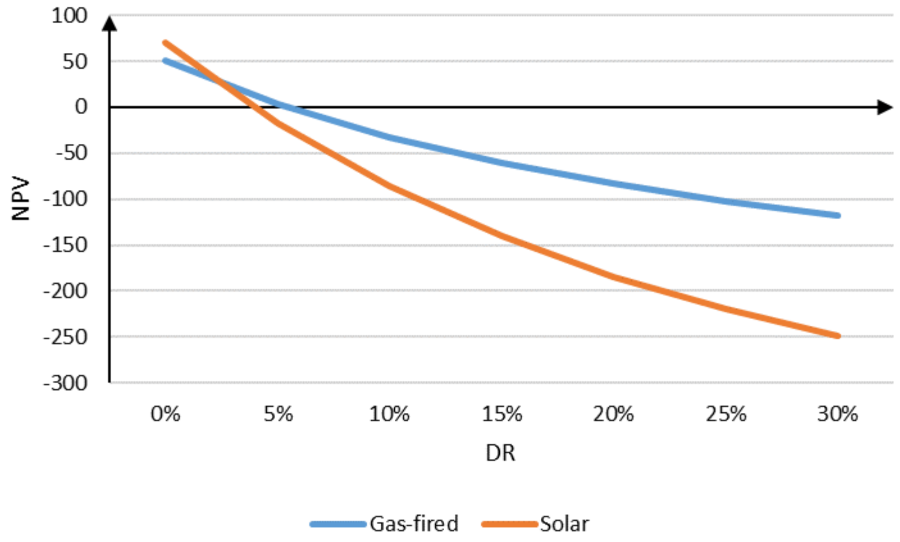
IRR function: Returns the internal rate of return for a series of cash flows represented by the numbers in values.

=IRR(value 0:value n)

3 Application – Energy Sector Case Studies

Sensitivity analysis

- Low discount rates will tend to favour projects with high capital costs, relative to running costs
- High discount rates will tend to favour projects with high running costs relative to capital costs



3 Application – Energy Sector Case Studies

Policy Impacts

In projects which are partly subsidised, it is recommended that the analysis is conducted with and without subsidies.

$$NPV(X,r) = -C_0 + B_s + \sum_{t=0}^{N} \frac{E \times (b-c)}{(1+r\%)^t}$$

If the costs and revenues might be affected by policy measure (e.g., carbon tax or subsidy for renewable), it is recommended that the potential impacts should be considered.

$$NPV(X,r) = -C_0 + \sum_{t=0}^{N} \frac{E \times (b + b_s - c - c_s)}{(1+r\%)^t}$$

3 Application – Energy Sector Case Studies

Policy Impacts

Example: gas-fired VS solar electric power generation

Scenario 1	Renewable Subsidy	Solar	200
Scenario 2	Carbon tax	Gas-fired	10 per year

Unit: $

3 Application – Energy Sector Case Studies

Summary of steps

- List the benefits and costs associated with a proposed investment, project or policy
- Quantify the costs and benefits (& place a monetary value on each – including externalities where appropriate), for each future year
- Choose a Discount Rate, and discount each of the costs and benefits in the relevant year, to find “present values”
- Sum up each of the sets of discounted costs and benefits, and calculate the ‘net present value’ (NPV)
- Calculate other performance indicators (i.e., IRR, DPR)
- Perform sensitivity analysis
- Recommend the alternative with the best overall performance across the various indicators and sensitivities

4 Conclusion

- Results may depend crucially on who carries out the appraisal and are sensitive to the assumptions and critical variable value
- Sensitivity analysis is essential to test all calculations for robustness
- It is vital to bring a range of assessment criteria to bear on decisions concerning appropriate energy options. Financial appraisal on its own is insufficient

Useful resources

Discounting:

- HM Treasury (annually) *'Green Book' Manual: Appraisal and Evaluation in Central Government*, available on-line at http://www.hm-treasury.gov.uk/d/green_book_complete.pdf
- Pearce,D.W.*etal*.(2003)“ValuingtheFuture:RecentAdvancesinSocialDiscounting”,*WorldEconomics*,4(2): 121-141.

Energy related:

- Tim Jackson's note, on SurreyLearn
- KhatibH (1997). *Financial and economic evaluation of projects in the electricity supply industry*. Institution of Electrical Engineers, London
- Johnson B (1994). Modelling Energy Technology Choices -Which Investment and Analysis Tools are Appropriate? *Energy Policy* 22(10) 877-883

General texts:

- LumbyS (any edition). *Investment Appraisal and Financial Decisions.* Chapman Hall
- Brent R J (2017). Cost-Benefit Analysis. Edward Elgar, Cheltenham UK
- Pearce DW (1998). Cost Benefit Analysis and environmental policy”. *Oxford Review of Economic Policy*, **14**(4): 84-100

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Lirong Liu
lirong.liu@surrey.ac.uk
www.surrey.ac.uk/ces

2 Method – Discounted Cash Flow Analysis

Discounted Payback Period (DPR)

DPR is the amount of time it takes to recover the cost of an investment. It is the length of time when the net present value equals to 0.

$$DPR = m + CPV_m / PV_{m+1}$$

Where

- DPR is the discounted payback period
- m is the year before the discounted payback period occurs
- CPV_m is the absolute cumulative present value in the year before recovery
- PV_{m+1} is the present value in the year after recovery

2 Method – Discounted Cash Flow Analysis

Discounted Payback Period (DPR)

Feasibility requirement:

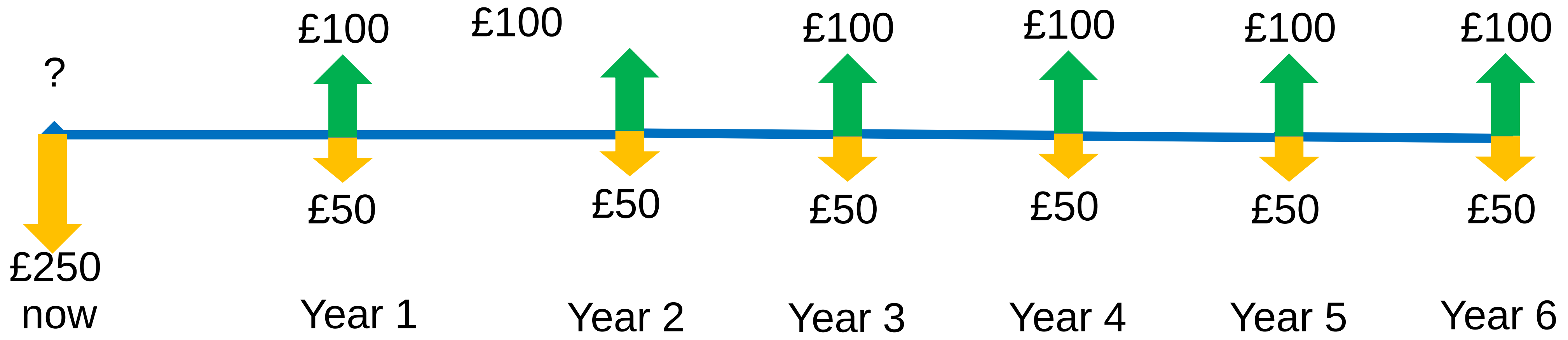
$$DPR \leq n$$

Where

- DPR is the discounted payback period
- n is the lifetime of the project

2 Method – Discounted Cash Flow Analysis

Example: gas-fired electricity generation



r = 5%:

PV:	-250	47.6	45.4	43.2	41.1	39.2	37.3
Cumulative PV: =	-250	-202.4	-157.0	-113.8	-72.7	-33.5	3.8

2 Method – Discounted Cash Flow Analysis

Example: gas-fired electricity generation

	now	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
r = 5%: PV:	-250	47.6	45.4	43.2	41.1	39.2	37.3
Cumulative PV: =	-250	-202.4	-157.0	-113.8	-72.7	-33.5	3.8

$$DPR = m + CPV_m / PV_{m+1}$$

- m is the year before the discounted payback period occurs
- CPV_m is the absolute cumulative present value in the year before recovery
- PV_{m+1} is the present value in the year after recovery

$$DPR = 5 + 33.5/37.3 = 5.9$$

Feasible

3 Application – Energy Sector Case Studies

The Generation Cost

The generation cost is the lowest revenue per unit of electricity generated to ensure the project's economic viability.

Financial appraisal for electricity generating projects:

Consider an electricity generating project X whose capital cost is \$ C_0 and annual electricity output is E kilowatt hours (kWh). Suppose that the running costs per unit of electricity generated are \$c per kWh and that the revenue earned per unit of electricity is \$b per kWh.

$$NPV(X,r) = -C_0 + \sum_{t=0}^{N} \frac{E \times (b-c)}{(1+r)^t}$$

3 Application – Energy Sector Case Studies

The Generation Cost

$$NPV(X,r) = -C_0 + \sum_{t=0}^{N} \frac{E \times (b-c)}{(1+r)^t}$$

Financial viability criterion:

$$-C_0 + \sum_{t=0}^{N} \frac{E \times (b-c)}{(1+r)^t} \geq 0$$

3 Application – Energy Sector Case Studies

The Generation Cost

$$NPV(X,r) = -C_0 + \sum_{t=0}^{N} \frac{E \times (b-c)}{(1+r)^t}$$

Financial viability criterion:

$$-C_0 + \sum_{t=0}^{N} \frac{E \times (b-c)}{(1+r)^t} \geq 0$$

$$-C_0 + E \times (b-c) \times \sum_{t=0}^{N} \frac{1}{(1+r)^t} \geq 0$$

(annuitisation factor)

$$-C_0 + E \times (b-c) \times A(r, N) \geq 0$$

(annuitisation factor)

3 Application – Energy Sector Case Studies

The Generation Cost

$$NPV(X,r) = -C_0 + \sum_{t=0}^{N} \frac{E \times (b-c)}{(1+r)^t}$$

Financial viability criterion:

$$-C_0 + E \times (b-c) \times A(r, N) \geq 0$$ (annuitisation factor)

$$b \geq c + \frac{C_0}{A(r,N) \times E}$$

$$g = c + \frac{C_0}{A(r,N) \times E}$$