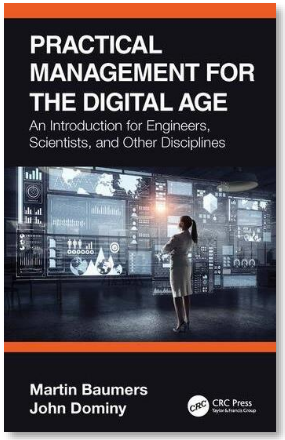
Department of Mechanical, Materials and Manufacturing Engineering

Evaluating flows of money

What we will talk about today:

Evaluating flows of money

- *The basic problem of time preference*
- *A project as a sequence of cash flows*
- *Interest rate and discount rate*
- *The minimum acceptable rate of return*
- *The internal rate of return*
- *Other aspects of the internal rate of return*



Lecture builds on Chapter 15 in Baumers and Dominy (2021) – Please read!

Context: Engineers in finance

Research has shown that just over half of engineering and technology graduates end up working in engineering occupations:

→ Many engineers end up in the financial industry

→ Certainly matches my observation…

This lecture provides some insight into the details of financial methods and concepts…

Source: https://engineering-jobs.theiet.org/article/why-do-engineering-graduates-choose-non-engineering-careers-hint-it-s-not-because-of-the-financial-sector-/

The basic intuition of time preference

When analysing flows of money associated with a product or activity, the aspect of time plays a crucial role:

- This is common in our everyday lives, not just in business or project management
- Would you prefer it if you were given £100 now or £100 in ten years' time?
- This concept is known as *time preference*, which reflects the current relative valuation placed on receiving a good (or sum of money) at an earlier date compared to receiving it at a later date

Viewing the finance of a project as cash flows

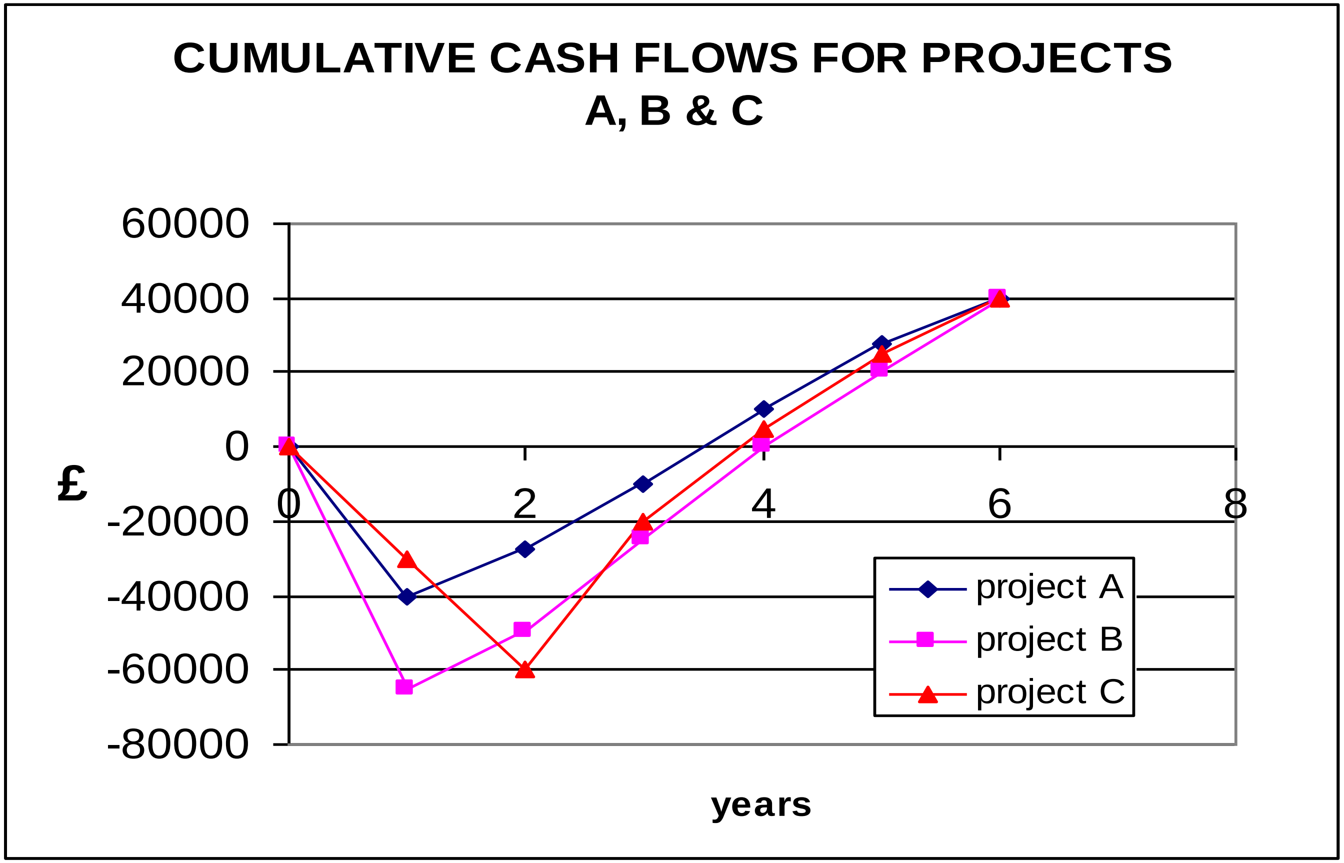
Projects or activities can be understood from a financial perspective by viewing them as a series of cash flows occurring over time…

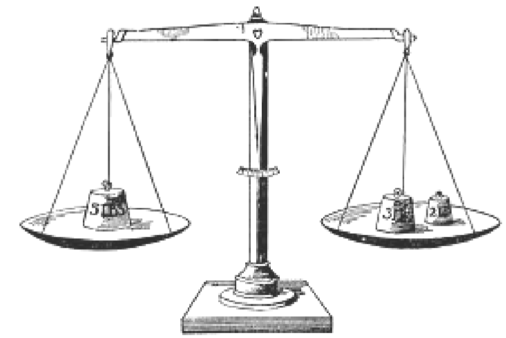
- For example, consider the following three projects:

	project a		project b		project c	
end of year	incremental cash flow in	cumulative cash flow out	incremental cash flow in	cumulative cash flow out	incremental cash flow in	cumulative cash flow out
0	0	0	0	0	0	0
1	-40000	-40000	-65000	-65000	-30000	-30000
2	12500	-27500	15000	-50000	-30000	-60000
3	17500	-10000	25000	-25000	40000	-20000
4	20000	10000	25000	0	25000	5000
5	17500	27500	20000	20000	20000	25000
6	12500	40000	20000	40000	15000	40000

- Which one would you choose?

Graphical comparison





- How do we select the best project?
- In this rather unreal case, the total return
  is the same and cannot separate the projects
- The next criteria would be the minimum investment for the return, in which case we would select project A
- But the maximum investment in project C occurs a year after B
- How should we accommodate this?

The cost of negative cash flow

- This modifies the previous model by adding the "cost of money".

  → In reality, a company will need to borrow or seek investment to fund a new project

  → At the very least, it will have to use cash that could be invested in some other way

- The basic requirements for a viable project are:
  - Return the money invested, plus
  - The cost of the investment, plus
  - Some additional true earnings

- In addition the project will have to compete with other projects and possibly quite dissimilar investments

What could be the sources?

- **Owners' capital** (or equity) – the share value of a company. This might include option to bring in new investors as owners, i.e. sell part of the company

- **Reserve capital** (or retained profit) – belongs to the owner's but is retained for reinvestment rather than taken as dividends

- **Loan** (or debt) capital – raised from banks for example. All involve an obligation to pay interest during the term of the loan and the capital at the end

Each of these will involve opportunity cost, either in interest or by the loss of income from some other investment!

→ If you don't remember what opportunity cost is, have a look at last year's material of Chapter 3 in the book!

Three simple methods of analysis

Example project

Initial investment of £100,000

Project proceeds / income

Year¤	Projected·cash·flows¤
0¤	-£100,000¤
1¤	£45,000¤
2¤	£35,000¤
3¤	£20,000¤
4¤	£20,000¤
5¤	£15,000¤

Payback Period:

- The time needed to recoup the initial investment: 3 years

Annual Average Proceeds (AAP):

- Average positive cash flows: £135,000 / 5 = £27,000

$$AAP = \frac{Net\ positive\ cash\ flow}{Duration}$$

Return On Investment (ROI):

- the returns of the project as a proportion of the initial investment: (£135,000- £100,000) / £100,000 = 35%

$$ROI = \frac{Net\ positive\ cash\ flow - Initial\ investment}{Initial\ investment}$$

But this is too simple, it doesn’t take into account *time preference*…

… i.e. how the present value of money changes over time!

Two major concepts: interest rate and discount rate

The simple methods presented so far are not very reliable, so we need methods that take time preference into account. This is done systematically by introducing two additional concepts:

The interest rate:

- The amount of money (i.e. the "interest") due per period of time where a sum of money (i.e. the "principal sum") is lent, borrowed or deposited

The discount rate:

- The discount rate reflects the return that could be obtained per unit of time, normally per year, on an investment with equal risk. It is the conceptual reverse of the interest rate

The interest rate

- The total interest arising from such an amount depends on:
    - the principal sum P
    - the interest rate r
    - the frequency with which interest is allocated
    - the length of time t over which the principal sum is loaned, borrowed or deposited

- Annual interest rate is the rate over a period of one year

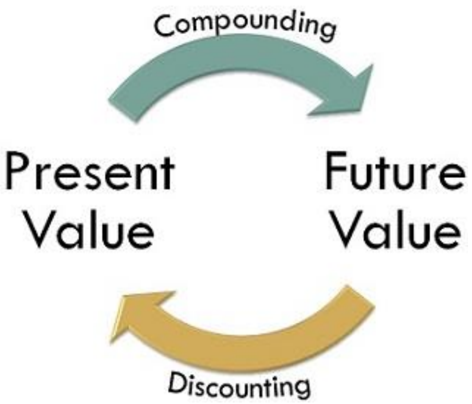
- Interest is normally reinvested, rather than paid out
    - Any interest received in the current or any future period is earned on the principal sum *and* all previously accumulated interest
    - This practice is known as **compound interest**

- The total accumulated value V of an investment with compound interest is:

$$V = P(1+r)^t$$

NUMERICAL EXAMPLES IN THE BOOK

The discount rate



- In finance, the "opposite" of calculating interest is using the technique of discounting to Net Present Value (NPV)

- The requires a discount rate, reflects the return that could be obtained per unit of time, normally per year

- Because it forms a variation of the concept of an interest rate, the symbol used for the discount rate is also *r*

- The NPV of a sum *S* can be calculated using the discount rate *r* and the time *t* at which *S* is paid out

$$Net\ Present\ Value = S\frac{1}{(1+r)^t} = S(1+r)^{-t}$$

Note that $(1+r)^{-t}$ is known as the "discount factor"

An example

- Instead of looking at investing principal *P* and eventually obtaining *V*, we can ask the question:

"If we want £100 in ten years time, how much do we need now?"

- Therefore, the amount we need now is said to be the Net Present Value (NPV) of £100 received in ten years time, subject to a discount rate *r* (say 6%)

Using the formula from the previous slide, the NPV of £100 receivable in ten years' time subject to a discount rate of 6% amounts to:

$$\text{NPV} = £100 \times (1 + 0.06)^{-10} = £55.84$$

The Minimum Acceptable Rate of Return (MARR)

The Minimum Acceptable Rate of Return (MARR)

But, as financiers, what would attract us to a particular investment?

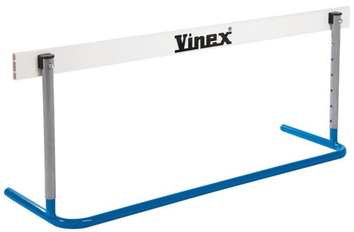
An Investment must:

- At least be at or above the current interest rate
- Provide an incentive to do more than put cash in a savings account
- Recognise risk

A percentage return that satisfies these criteria is known as the

"MINIMUM ACCEPTABLE RATE OF RETURN"

- This is why the MARR is also known as the "hurdle rate"



More on MARR

But to be realistic, the MARR must consider a number of points:

- Current available interest rate
- Current inflation level
- Some allowance for risk
  → for example, do one in ten projects fail?
- Some increment above the basic risk-free interest rate to encourage investors (who are generally averse to risk)

Calculating MARR

Note that the idea of NPV applies to all flows of money, both inflows and outflows of cash

- This means we can exploit discounting to NPV to calculate the discounted returns of an investment
- But only if we can state the appropriate discounting rate *r*

The first step in applying MARR is to discount each cash flow to NPV. In the second step, the discounted cash flows are added up

- This allows the analyst to determine if the overall cumulative present value of the project in five years' time is positive (and thus worthwhile)

An example calculation of MARR

The following table presents a worked example with MARR (*r*) set at 18%

The initial investment in Year 0 (£65k) is not discounted because it is paid instantaneously

Using the discount factor $(1+r)^{-t}$ makes the calculation clearer

Year	Cash flow	Discount factor	Cash flow at NPV	Cumulative present value
0	-£65,000	1.000	-£65,000	-£65,000
1	£15,000	0.847	£12,712	-£52,288
2	£25,000	0.718	£17,955	-£34,334
3	£25,000	0.609	£15,216	-£19,118
4	£20,000	0.516	£10,316	-£8,802
5	£20,000	0.437	£8,742	-£60

The project generates positive cash flows in every year (Year 1 to Year 5)

But the overall cumulative present value of the project is slightly below zero (-£60), so it is unacceptable.

Problems with using MARR

- The main disadvantage is that, as a technique based on NPV, MARR requires setting *r* as an arbitrary parameter

- In some respects this is a strength, since it allows the analyst to build in other aspects, such as risk and possibly personal interest

Note that the analysis that we have completed here considers interest that is paid annually at the end of the year

→ These methods also exist as continuous versions or with different time periods (e.g. monthly)

A more advanced method:

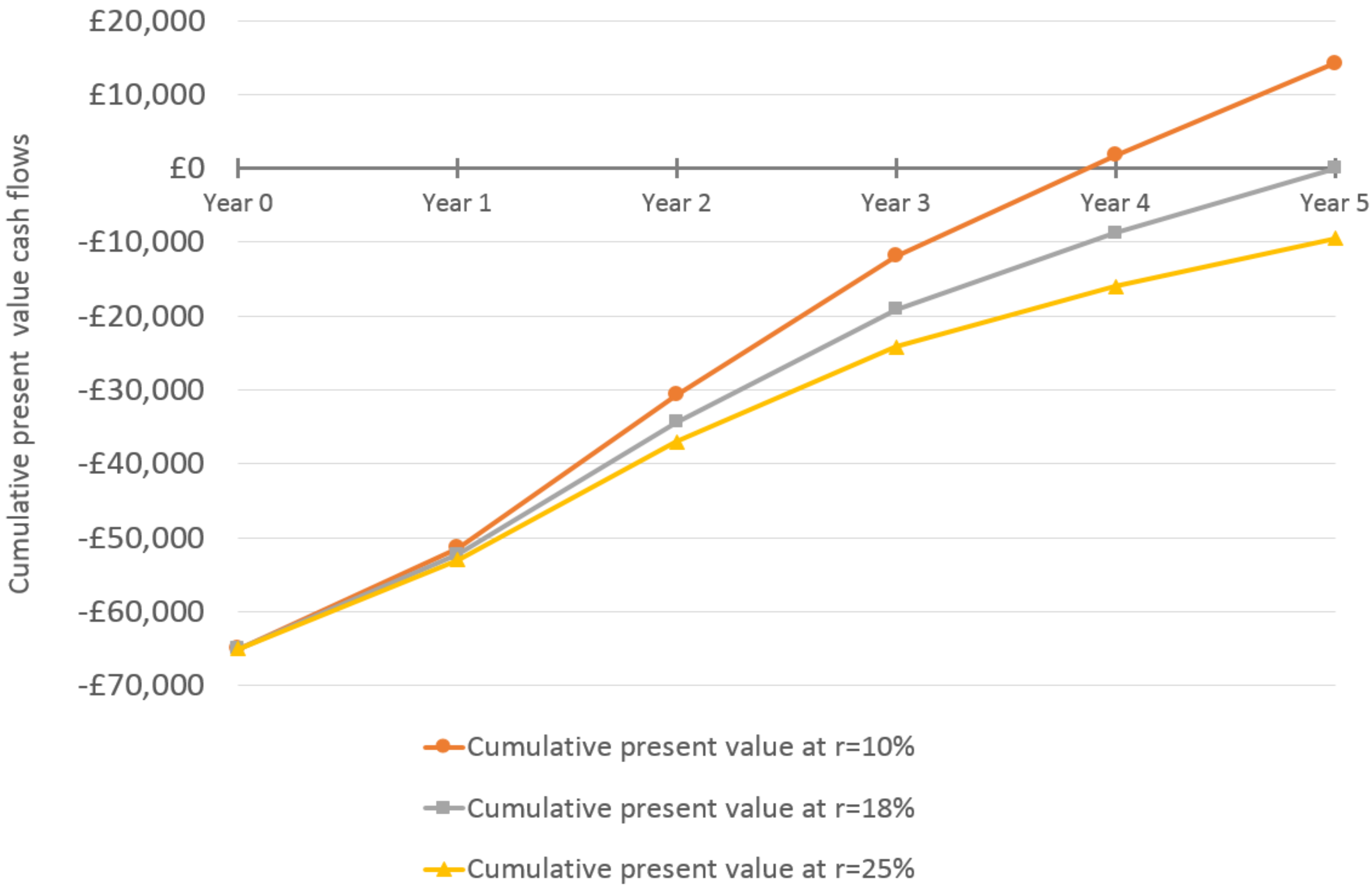
the Internal Rate of Return (IRR)

The Internal Rate of Return (IRR)

IRR forms an approach to the evaluation of cash flows that avoids setting and arbitrary rate of return. While the method may initial appear complex, its logic is closely related to that of MARR:

- We have seen that the cumulative present value at the end of a project can be positive, zero or negative
- As a method IRR requires us to establish at which *r* the cumulative present value at the end of the project is zero
- The most intuitive way to explain IRR is to provide a numerical example
- We will set *r* to 10%, 18% and 25% and calculate the cumulative NPV for each scenario

Graphical comparison of cumulative NPV



Interpreting the Internal Rate of Return (IRR)

- A MARR of 18% yields a cumulative present value at the end of the project at -£60, which is close to zero

- So the IRR is close to 18%. In fact it is approximately 17.96%

- But what is the interpretation of this?

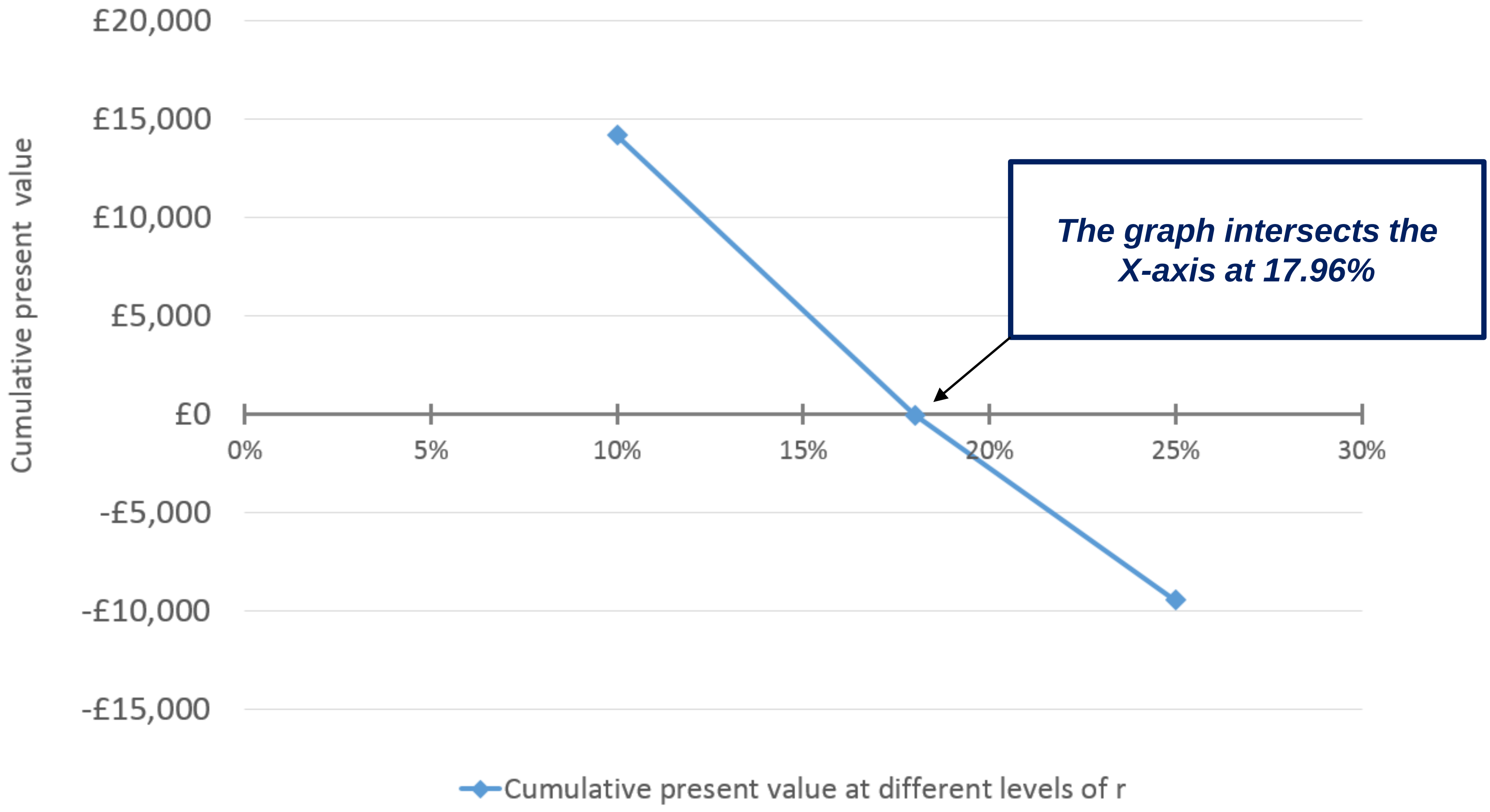
At the IRR, the discounted investments (negative cash flows) are equal to the sum of the discounted returns (positive cash flows). In other words, at IRR the outgoing and incoming cash flows of the project are in balance, subject to discounting

- Mathematically:

$$S_0 + S_1(1+r)^{-1} + S_2(1+r)^{-2} + \cdots + S_T(1+r)^{-T} = \sum_{t=0}^{T} S_t(1+r)^{-t} = 0$$

Finding the Internal Rate of Return (IRR)

The recommended way to determine IRR is through graphical analysis. This is done by plotting the cumulative present value of the project against at different levels of *r:*



Making sense of the IRR

As a measure of profitability, the investor or project initiator will choose a project with the highest possible IRR.

But there is also a relationship between the IRR and "fixed income investments" (i.e. bonds):

The IRR equates to the interest received annually on a "fixed income investment" (a bond) which is equivalent to the investment

- In fixed income investments, the interest is paid out annually, hence there is no compounding

- The overall specifications of an equivalent bond (one investment, fixed annual interest) can be established using this method, which is useful for comparisons against alternative investments

An equivalent fixed income investment

- The equivalent fixed income investment has the following cash flow profile:

Year	Incremental cash flow	Cumulated cash flow	Cumulative present value
0	-£65,000	-£65,000	-£65,000
1	£11,674	-£53,326	-£55,103
2	£11,674	-£41,651	-£46,713
3	£11,674	-£29,977	-£39,601
4	£11,674	-£18,302	-£33,571
5	£76,674	£58,372	£0

- Note how the principal sum is returned at the end (in Year 5) on top of the fixed interest payment (17.96% per year).

→ Thus we now know that a fixed income investment equivalent to our project (same IRR) yields a total cumulative cash flow of £58,372 over five years…

A final step: adjusting for inflation

Generally the cost of items will, on average, increase each year – which is captured in the inflation rate *f:*

- Inflation *can* be included in both the MARR and IRR calculations by forming an inflation factor analogous to the discount factor, deflating a future cash flows *S* over *t* years:

$$Deflated\ Value = S\frac{1}{(1+f)^t} = S(1+f)^{-t}$$

- After deflating the NPV the discounting method can be applied, as before…

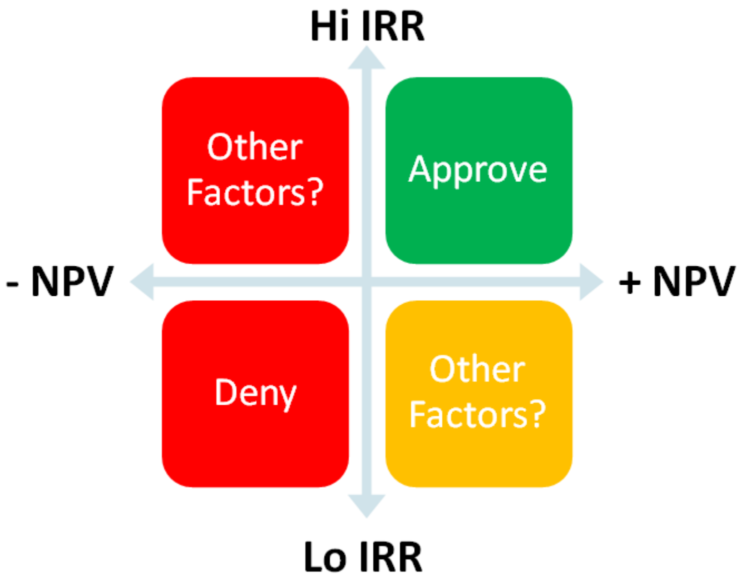
Year	Cash flow	Inflation factor	Deflated cash flow	Discount factor	Cash flow at NPV	Cumulative present value
0	-£65,000	1.000	-£65,000	1.000	-£65,000.000	-£65,000
1	£15,000	0.943	£14,151	0.893	£12,634.771	-£52,365
2	£25,000	0.890	£22,250	0.797	£17,737.493	-£34,628
3	£25,000	0.840	£20,990	0.712	£14,940.611	-£19,687
4	£20,000	0.792	£15,842	0.636	£10,067.797	-£9,619
5	£20,000	0.747	£14,945	0.567	£8,480.287	-£1,139

… where f = 6% and r = 12%

But what happens if the calculated measures don't result in favouring the same project option?

In this case the skilled investor would use experience and consider factors, such as:

- Total investment
- Rate of investment
- Total cash return



Different investors might come to different conclusions based on their individual requirements and expectations!

Lecture summary in three points

- Learnt about time preference, interest and the discount rate
- Familiar with discounting to NPV
- Can use MARR and IRR to evaluate projects

… read the book for more detail and information!

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Thank you!