How to Make Financial Decisions

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What Is An Investment?

		Person	**Company**
Real	***Tangible***	Renovate a kitchen	Build a new factory
	Intangible	Attend university / this lecture	Increase parental leave
Financial		Buy shares	Buy back shares

- Investments all involve
  - Spending cash today
  - Receiving cash in the future
- Why can't you simply sum up the cash flows (calculate net cash)?
  - A certain £1 is worth more than a risky £1

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Lecture 4: "How to Measure and Manage Risk"

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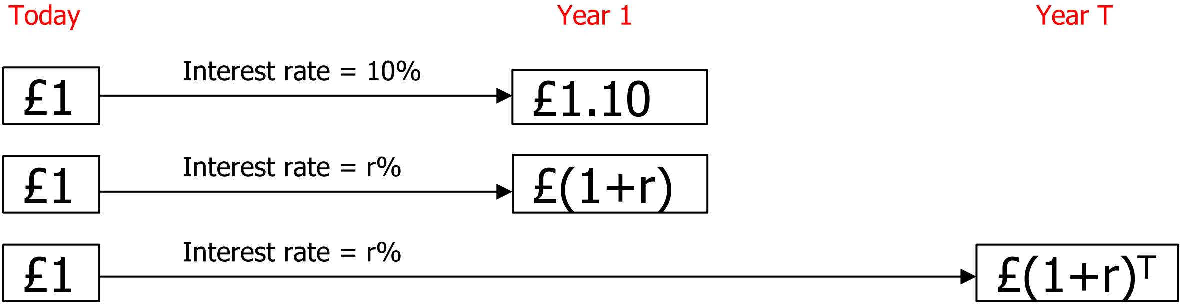
- Investments all involve
  - Spending cash today
  - Receiving cash in the future
- Why can't you simply sum up the cash flows (calculate net cash)?
  - A certain £1 is worth more than a risky £1
  - £1 today is worth more than £1 tomorrow due to the *time value of money*
- These differences seem to depend on personal taste


£10
£10
£10
£5

The Time Value of Money

- Money has *time value* because it can be invested elsewhere

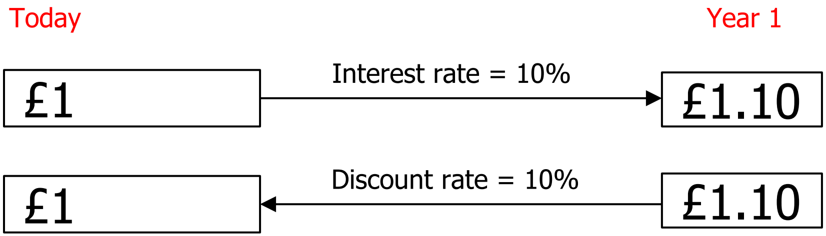


The Future Value of Money

- The *future value* of £1 is £$(1+r)^T$. £1 *compounded* gives £$(1+r)^T$ in the future
- The *future value* of £C is £$C(1+r)^T$
- The future value is given by the *interest rate r* and *time period T*
  - <u>Not</u> your impatience or time preference. It's objective
  - Time value depends on *opportunity cost*, which is independent of preferences

The Present Value of Money

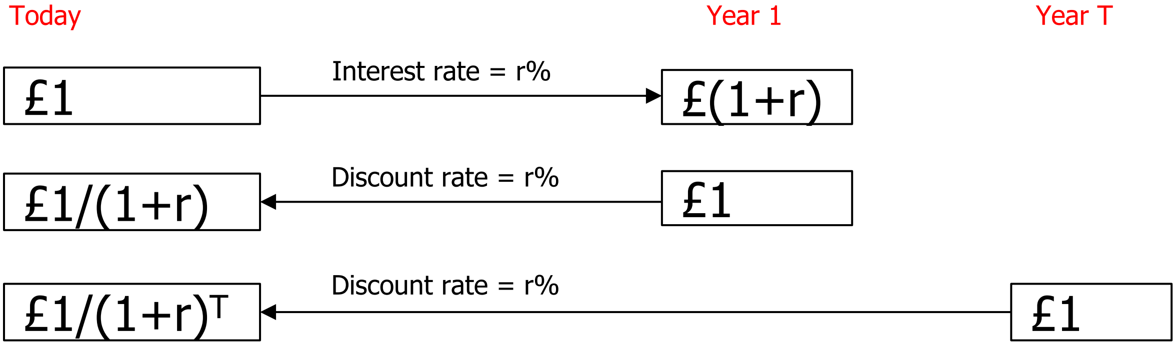
- How much is future money worth today – what is its *present value*?



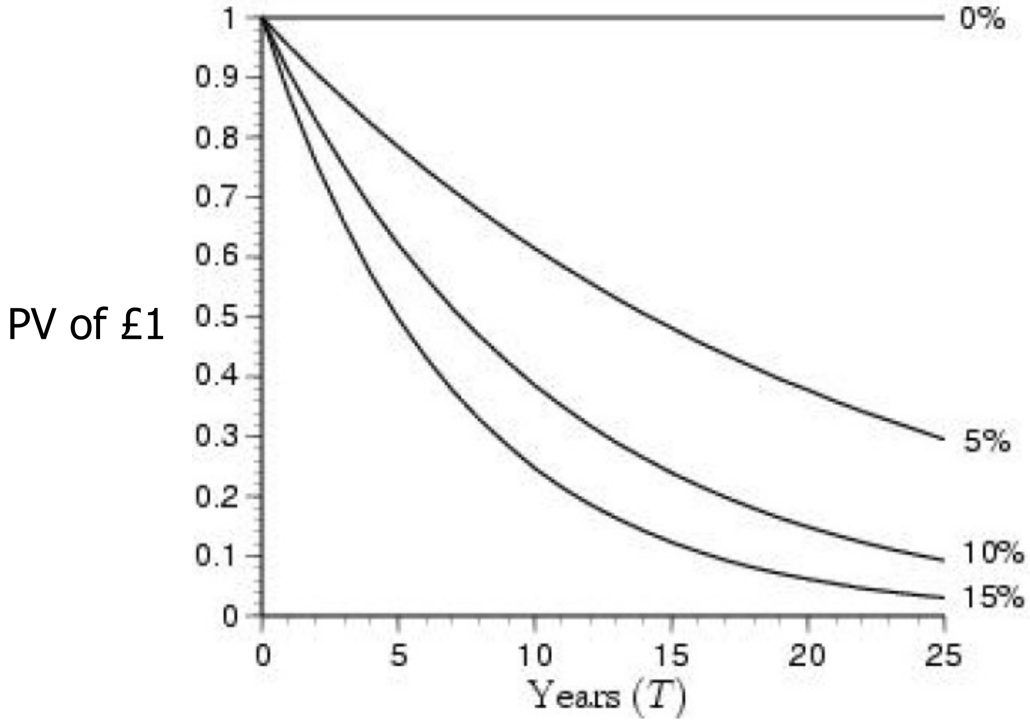
- We *compound* cash flows to get from the present to the future
- We *discount* cash flows to get from the future to the present

The Present Value of Money

- How much is future money worth today – what is its *present value*?

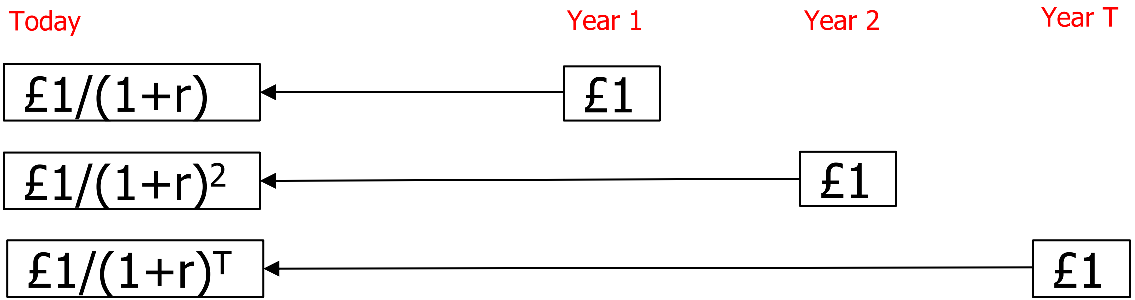


- The *present value* of £C is $£C/(1+r)^T$
  - Again, depends on *opportunity cost*, which is independent of preferences


PV of £1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0%
5%
10%
15%
0
5
10
15
20
25
Years (T)

The Present Value of an Investment

- The present value of a sequence of cash flows is the sum of the present values of each cash flow



- The *present value* of £1 each year is $£1/(1+r) + £1/(1+r)^2 + ... + £1/(1+r)^T$

The Net Present Value of an Investment

- The *present value* of £1 each year is $\frac{1}{(1+r)} + \frac{1}{(1+r)^2} + \ldots + \frac{1}{(1+r)^T}$
- The *present value* of £C_1 each year is $\frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_T}{(1+r)^T}$
- The *present value* of £C_1 each year is $\sum_{t=1}^{T} \frac{C_t}{(1+r)^t}$
- The *net present value* of an investment is $-C_0 + \sum_{t=1}^{T} \frac{C_t}{(1+r)^t}$
- We take an investment if the *net present value* is positive
  - $\sum_{t=1}^{T} \frac{C_t}{(1+r)^t} > C_0$
  - Present value of future benefit > Present cost

An Example

- You’re considering building a gym. The interest rate is 8% and the estimated cash flows from the gym are as follows:

Year 0	Year 1	Year 2	Year 3
-1,000	200	350	600

- The *net present value* of the gym is -1000 + $\frac{200}{1.08} + \frac{350}{1.08^2} + \frac{600}{1.08^3}$

  = -38 so <u>no-one</u> should build
- Simple addition would give you -1000 + 200 + 350 + 600 = 150
  - But if you put 1,000 in the bank, you’d get 1000×1.08^3 = 1,260 in 3 years

An Example

- You're considering building a gym. The interest rate is 5% and the estimated cash flows from the gym are as follows:

Year 0	Year 1	Year 2	Year 3
-1,000	200	350	600

- The *net present value* of the gym is -1000 + $\frac{200}{1.05} + \frac{350}{1.05^2} + \frac{600}{1.05^3}$ = 26 so <u>everyone</u> should build
- A lower interest rate reduces the *opportunity cost* of investing in the gym, making it more attractive

Shortcuts

- You hope the gym won't close after 3 years – it will last for 50

$$\frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \frac{C_4}{(1+r)^4} + \frac{C_5}{(1+r)^5} + \frac{C_6}{(1+r)^6} + \frac{C_7}{(1+r)^7} + \frac{C_8}{(1+r)^8} + \frac{C_9}{(1+r)^9} + \frac{C_{10}}{(1+r)^{10}}$$
$$+ \frac{C_{11}}{(1+r)^{11}} + \frac{C_{12}}{(1+r)^{12}} + \frac{C_{13}}{(1+r)^{13}} + \frac{C_{14}}{(1+r)^{14}} + \frac{C_{15}}{(1+r)^{15}} + \frac{C_{16}}{(1+r)^{16}} + \frac{C_{17}}{(1+r)^{17}} + \frac{C_{18}}{(1+r)^{18}} + \frac{C_{19}}{(1+r)^{19}}$$
$$+ \frac{C_{20}}{(1+r)^{20}} + \frac{C_{21}}{(1+r)^{21}} + \frac{C_{22}}{(1+r)^{22}} + \frac{C_{23}}{(1+r)^{23}} + \frac{C_{24}}{(1+r)^{24}} + \frac{C_{25}}{(1+r)^{25}} + \frac{C_{26}}{(1+r)^{26}} + \frac{C_{27}}{(1+r)^{27}} + \frac{C_{28}}{(1+r)^{28}}$$
$$+ \frac{C_{29}}{(1+r)^{29}} + \frac{C_{30}}{(1+r)^{30}} + \frac{C_{31}}{(1+r)^{31}} + \frac{C_{32}}{(1+r)^{32}} + \frac{C_{33}}{(1+r)^{33}} + \frac{C_{34}}{(1+r)^{34}} + \frac{C_{35}}{(1+r)^{35}} + \frac{C_{36}}{(1+r)^{36}} + \frac{C_{37}}{(1+r)^{37}}$$
$$+ \frac{C_{38}}{(1+r)^{38}} + \frac{C_{39}}{(1+r)^{39}} + \frac{C_{40}}{(1+r)^{40}} + \frac{C_{41}}{(1+r)^{41}} + \frac{C_{42}}{(1+r)^{42}} + \frac{C_{43}}{(1+r)^{43}} + \frac{C_{44}}{(1+r)^{44}} + \frac{C_{45}}{(1+r)^{45}} + \frac{C_{46}}{(1+r)^{46}}$$
$$+ \frac{C_{47}}{(1+r)^{47}} + \frac{C_{48}}{(1+r)^{48}} + \frac{C_{49}}{(1+r)^{49}} + \frac{C_{50}}{(1+r)^{50}}$$

- Fortunately, there are shortcuts to help us out

Perpetuities

- What is the present value of C that is paid every year, forever (= in perpetuity?)
- $PV = \frac{C}{1+r} + \frac{C}{(1+r)^2} + \frac{C}{(1+r)^3} + \ldots$
- $PV = \frac{C}{r}$

Perpetuities: An Example

- In the 1800s, the British government wanted to consolidate the huge debt accumulated during the Napoleonic wars
- It issued a single perpetual bond (or *consol*) and used the proceeds to pay back the existing debt


1877 Four Per Cent. Consols 1907
of the United States.
Washington. July 1st 1877.
THE UNITED STATES OF AMERICA
26455
Are Indebted To
IN THE SUM OF
FIFTY DOLLARS
This Bond is issued in accordance with the provisions of an Act of Congress entitled "An Act to authorize the refunding of the National Debt," approved July 14, 1870, amended by an Act approved January 20, 1871, and is redeemable at the pleasure of the United States, after the first day of July A.D. 1907, in coin of the standard value of the United States on said July 14, 1870, with interest in such coin from the day of the date hereof at the rate of four per centum per annum, payable quarterly on the first day of October, January, April and July in each year. The principal and interest are exempt from the payment of all Taxes or Duties of the United States, as well as from Taxation in any form, by or under State, municipal or local authority.
Transferable on the Books of this Office
Entered
Recorded
ACT OF JULY 14th 1870.
PRINCIPAL AND INTEREST PAYABLE IN COIN AT THE TREASURY OF THE UNITED STATES
50
FIFTY

Perpetuities: An Example

- Suppose the current interest rate is 3% in the US. How much should a consol with a coupon of 4% and a face value of $50 cost?
- Interest each year is 4% × $50= $2
- $PV = \frac{2}{0.03}$= $66.7
- Does this make sense?
- Premium bond (see Lecture 1)

Perpetuities: An Example

- Suppose the current interest rate is **4%** in the US. How much should a consol with a coupon of 4% and a face value of $50 cost?
- Interest each year is 4% × $50= $2
- $PV = \frac{2}{0.04}$= $50
- Does this make sense?
- Par bond (see Lecture 1)

Perpetuities: An Example

- Suppose the current interest rate is **5%** in the US. How much should a consol with a coupon of 4% and a face value of \$50 cost?
- Interest each year is 4% × \$50= \$2
- $PV = \frac{2}{0.05}$= \$40
- Does this make sense?
- Discount bond (see Lecture 1)

The Link Between Bond Prices and Interest Rates

Interest Rate	Price of Bond
3%	$66.7
4%	$50
5%	$40

The Link Between Bond Prices and Interest Rates

<u>Outside</u> Interest Rate	**Price of Bond**
3%	$66.7
4%	$50
5%	$40

- Just like the value of the gym rose when the outside interest rate fell

Growing Perpetuities

- What is the present value of C that grows by g% every year, forever (= in perpetuity?)
- $PV = \frac{C}{1+r} + \frac{C(1+g)}{(1+r)^2} + \frac{C(1+g)^2}{(1+r)^3} + \ldots$
- $PV = \frac{C}{r-g}$
- Does this make sense?

Growing Perpetuities: An Example

- You're considering building a gym. The interest rate is 8% and the estimated cash flows from the gym are as follows:

Year 0	**Year 1**	**Year 2**	**Year 3 …**
-1,000	200	200×1.02	200×1.02^2 …

- The cash flows are expected to grow by 2% forever
- The *net present value* of the gym is -1000 + $\frac{200}{0.08-0.02}$

  = 2,333 so build the gym

Annuities

- What is the present value of C that is paid every year, for T years?
- $PV = \frac{C}{1+r} + \frac{C}{(1+r)^2} + \ldots + \frac{C}{(1+r)^T}$
- $PV = \frac{C}{r}\left[1 - \frac{1}{(1+r)^T}\right]$

Annuities: An Example

- I am taking out a £100,000 mortgage at a fixed interest rate of 3%. The mortgage will be repaid each year over 25 years. How much will I need to pay back each year?
- $PV = \frac{C}{r}\left[1 - \frac{1}{(1+r)^T}\right]$
- $100{,}000 = \frac{C}{0.03}\left[1 - \frac{1}{1.03^{25}}\right]$
- C = £5,743
- Does that make sense? Total payout is 25 × £5,743 = £143,570

Practical Tips When Using NPV

- Include *incremental* cash flows, and only incremental cash flows
  - Include opportunity costs (including your own time, spare capacity)
  - Ignore sunk costs
- Use nominal cash flows that include inflation
  - Because the discount rate is nominal
- Cash flows should be after tax

Summary

- An *investment* is a claim to future cash flows
- £1 today grows to £$(1+r)^T$ in year T due to *time value of money*
- £1 in year T has a *present value* of £$1/(1+r)^T$ today
- The *net present value* of an investment is $-C_0 + \sum_{t=1}^{T} \frac{C_t}{(1+r)^t}$
  - We take an investment if NPV is positive
  - NPV falls with the interest rate r as this increases the *opportunity cost* of investing
- The NPV of a growing perpetuity is $PV = \frac{C}{r-g}$
- The NPV of a mortgage is $PV = \frac{C}{r}\left[1 - \frac{1}{(1+r)^T}\right]$
- Include all incremental cash flows, and only incremental cash flows