EC334 Topics in Financial Economics
First Seminar

Junxi Liu

January 2024

Welcome!

- I am Junxi Liu, a PhD student in the department of economics。
- There are a total of four seminar classes for EC334, one every two weeks. We will be mostly focus on real options and agent problems in the seminars, and also covering other topics.
- As I have classes both on odd weeks and even weeks, from now on I will simply use “First Seminar”, etc, to refer to classes.
- You are from a wide range of majors: Economics, PPE, MORSE, Politics, Math, Exchange student, and many more…
  - The main focus of the seminars will be giving you hands-on experience to use techniques and skills to solve exercises and problems
  - The underlying theme of the seminars will be making sure you understand the intuition and logic of concepts and models

Logistics

- You will find all information and materials of seminar classes on my website: https://warwick.ac.uk/fac/soc/economics/staff/jliu/teaching/
- I will also send materials to you via email
- My office hours (week 3-10 of term 2):
  - Fridays, 12:00-14:00, S2.80
  - Book on my website: https://warwick.ac.uk/fac/soc/economics/staff/jliu/teaching/officehour/
- I will be obliged to take attendances
  - If you couldn't make your seminar class, the easiest way is to ***go to another seminar of mine***, and I will record your attendance then.
  - Information on the time and location of all classes I teach can be found on my website.
  - If none of them suits you, please contact the UG office to mitigate your absence.

Logistics

Junxi Liu ▶ **Teaching**

Teaching

Contact Email: junxi.liu.1@warwick.ac.uk

Office hours for Term 2, 2023-2024: Fridays 12:00-14:00, S2.80, Week 1 - 10.

Please book using this link before you come.

2023-2024

EC334 (Seminars): Topics in Financial Economics: Corporate Finance and Markets, Term 2

EC104 (Seminars): The World Economy: History & Theory, Term 2

EC104 (Seminars): The World Economy: History & Theory, Term 1; Teaching Evaluation

2022-2023

Warwick Summer School (seminars): International Business and Finance, Summer School

EC334 (seminars): Topics in Financial Economics: Corporate Finance and Markets, Term 2; Teaching Evaluation

EC202 (seminars): Microeconomics 2, Term 1; Teaching Evaluation

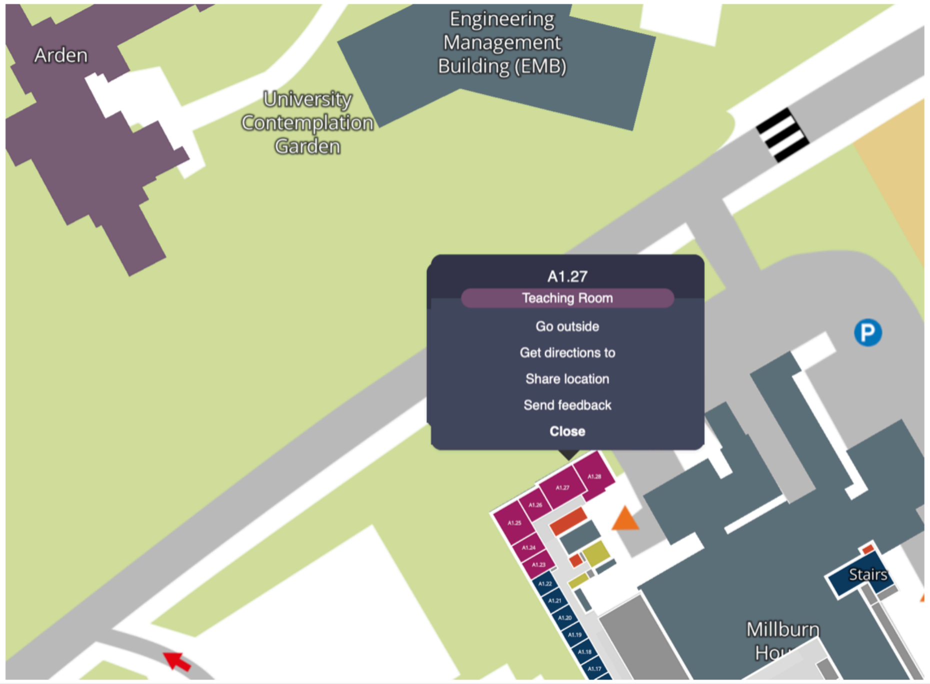
Junxi Liu ▶ Teaching ▶ **EC334 - 2024**

EC334 - 2024

All My Seminars Take Place on Mondays:

- Week 17; 19; 21; 23 (the 3rd, 5th, 7th, 9th week of term 2):
  - 16:00 - 17:00, A1.27 (Millburn)
  - 17:00 - 18:00, F25b (Millburn)
- Week 18, 20, 22, 24 (the 4th, 6th, 8th, 10th week of term 2):
  - 16:00 - 17:00, A1.27 (Millburn)

Location Map (please use the orange triangle as entrance)



Introduction: value of time

- Let's do some money talk…
  - If your friend wants to borrow £1000 from you, and promise to pay back £1000 in five years, will you be happy to do that?
  - Time is valuable! Inflation, risk-free assets, etc.
  - The value of time, in the simplest form, is the rate of return, ***r***
  - Therefore, for every amount of money in the future, if we want to make meaningful comparisons, we would like to use a common benchmark — usually the ***present value*** of that amount

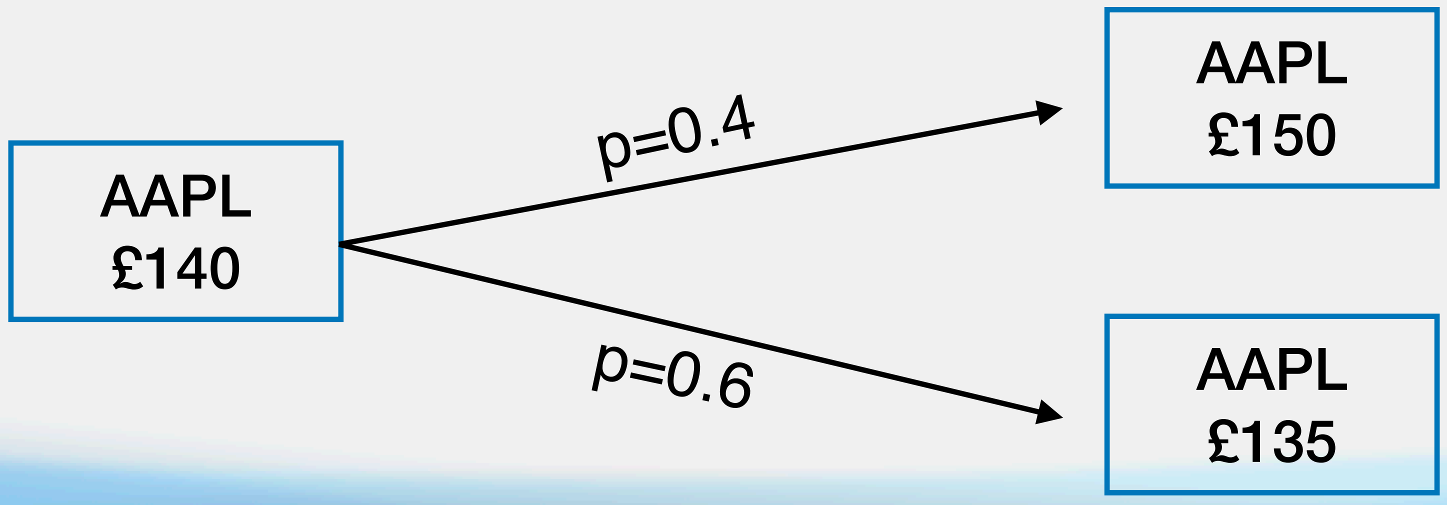
$$PV = FV \frac{1}{(1+r)^n}$$

PV = present value
FV = future value
r = rate of return
n = number of periods

  - For example, if the risk-free interest is 5%, the present value of £1000 one year later will be 1000/1.05 = £952.38

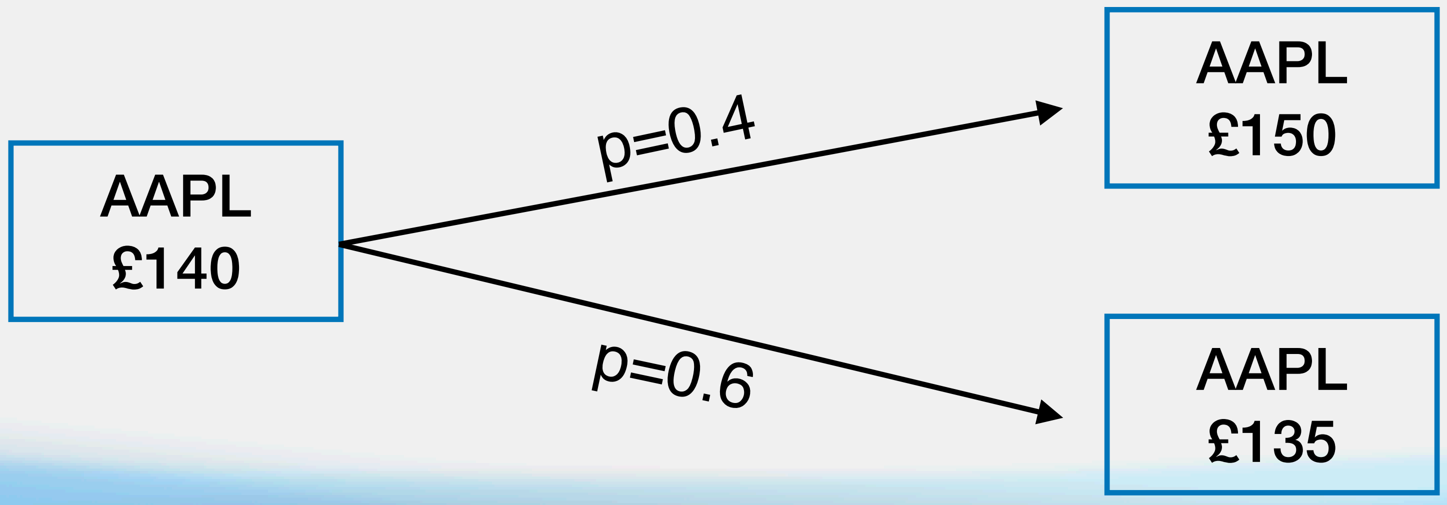
Introduction: derivatives

- Risk-free is good, but the world is full of risks.
- The simplest (as it only involves probability and numeric value) example will be the price of a stock can go up or down.
- To cater for people's *different perception of risks*, derivatives, a contract that derives its value from the performance of an underlying entity, are created
- Suppose the price of AAPL is £140 currently, and you firmly believe that it only has two possibility in one month: it can go up to £150 with probability 40%, and can go down to £135 with probability 60%



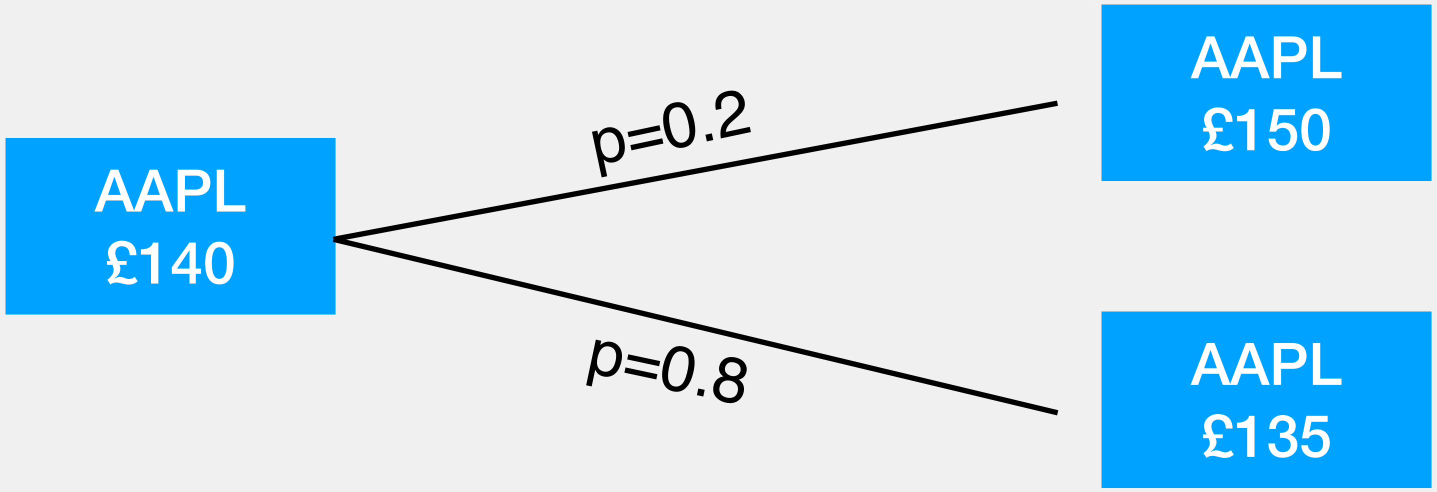
Introduction: options

- On paper, if you buy one share of AAPL now, your expected return will be 0.4*(150-140)+0.6*(135-140) = £1
- You want to make more money than this, so you look at options
  - OPTION1: (*call option*) trading at £2 per share, it gives you the right to buy in AAPL one month later at the price of £141
    - If the price is £150, your profit will be (£150-£141-£2) = £7 per share
    - If the price is £135, your loss will simply be £2 per share
    - According to your risk perception (40% to be £150 and 60£ to be £135), your expected profit will be 7*0.4-2*0.6 = £1.6
    - This option is a better deal!



Introduction: options

- It will be different for another person with different views
  - OPTION1: (call option) trading at £2 per share, it gives the right to buy in AAPL one month later at the price of £141
    - If the price is £150, their profit will be (£150-£141-£2) = £7 per share
    - If the price is £135, their loss will simply be £2 per share
    - According to their risk perception (20% to be £150 and 80£ to be £135), their expected profit will be 7*0.2-2*0.8 = -£0.2
  - This option is not a good deal for them — they will instead, sell this option



Let’s move to our topic, *Real* options

- A real option gives a firm's management *the right, but not the obligation* to undertake certain business opportunities or investments.
- Real option refer to projects involving tangible assets
- Real options can include the decision to expand, defer or wait, or abandon a project entirely.

In company terms…

- *Value of the firm* - the expected net present discounted value of the returns to its activities
- *NPV (Net Present Value) rule*:
  - firm estimates future revenues and investment and other costs
  - discounts at a suitable opportunity cost rate (WACC= weighted average cost of capital)
  - pick projects that offer positive NPV
  - "net" in the sense that investment needs to be subtracted

$$NPV = -Investment_0 + \sum_{t=1}^{N} \frac{E(FreeCashFlow_t)}{(1+WACC)^t}$$

When $-1 < r < 1$

$$\lim_{n\to\infty} \sum_{k=1}^{n} a * r^k = \lim_{n\to\infty} a * \frac{r(1-r^n)}{1-r} = a * \frac{r}{1-r} = \frac{a}{\frac{1}{r}-1} \longrightarrow \sum_{t=1}^{\infty} \frac{a}{(1+WACC)^t} = \frac{a}{WACC}$$

$$Geometric\ series: \sum_{k=1}^{n} r^k = \frac{r(1-r^n)}{1-r}$$

NPV Exercise

- You can decide today to invest in *a machine that costs £1600*, paid regardless of the state of nature *at the end of a year*
- At the end of year, the machine produces *one unit of product*, which is worth £300 or £100, with *50-50 probability*
- The weighted average cost of capital (WACC) is 10%
- What is the NPV today if the machine can be only used for one period? What is the NPV today if the machine continues to produce forever and the price level stays the same forever?

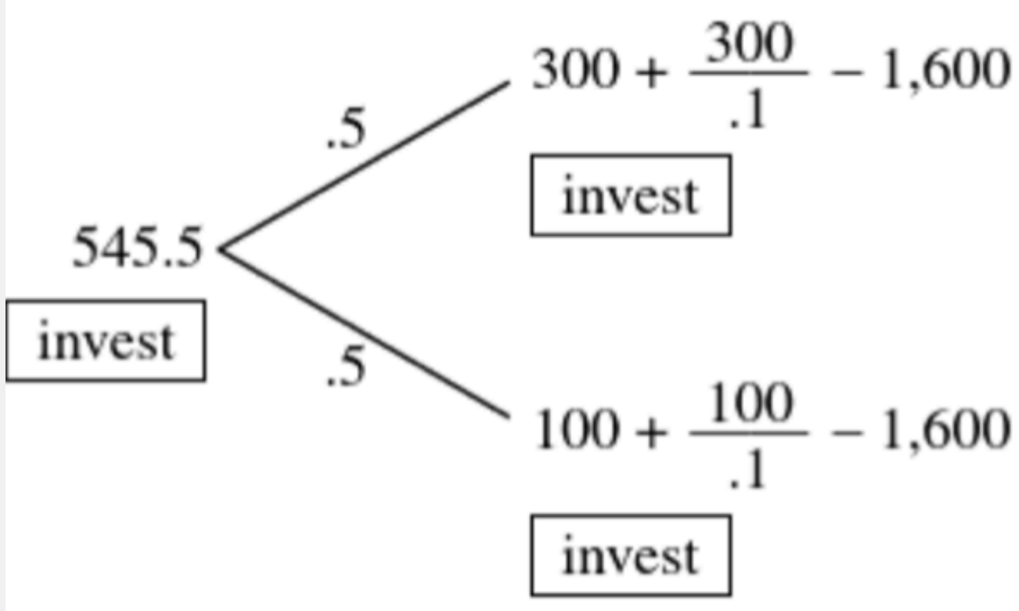
NPV Exercise

$$\text{NPV(one period)} = \frac{(-1600 + 0.5^{*}300 + 0.5^{*}100)}{1.1} = -1272.7$$

$$NPV_1 = -1,600 + [0.5(300) + 0.5(100)] + \sum_{t=1}^{\infty} \frac{0.5(300) + 0.5(100)}{(1+0.1)^t}$$

$$= -1,600 + 200 + \frac{200}{0.1} = 600$$

$$NPV_0 = 600/1.1 = 545.5.$$



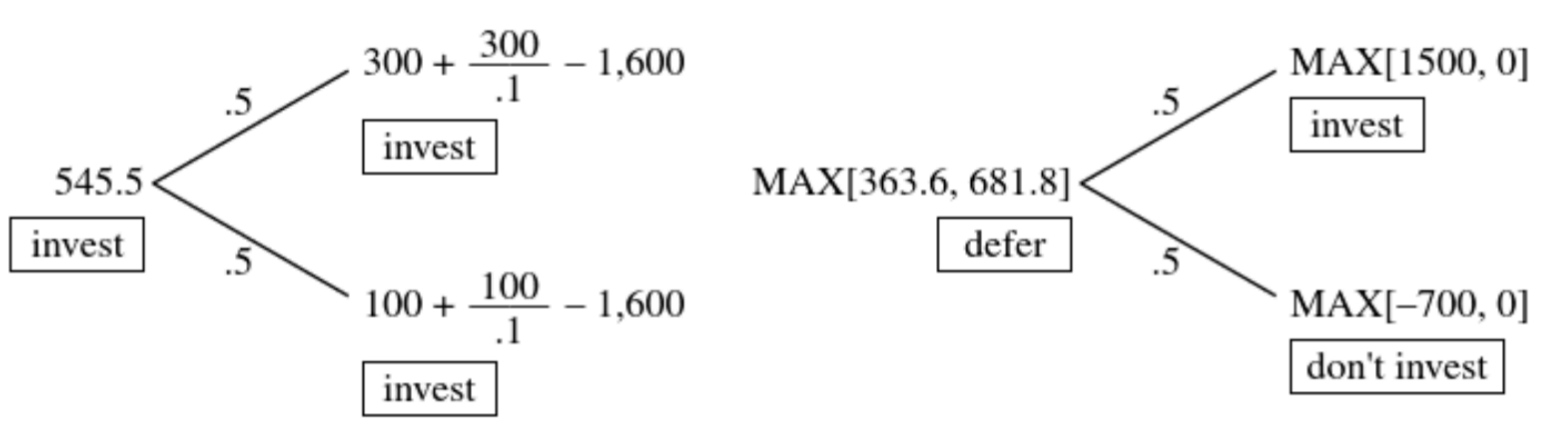
(a) NPV assuming precommitment

Option Exercise

- According to the NPV criterion, shareholders' wealth increases by £545.50 if we take the project, and so we do.
- What if you have, you would've guessed, *an option*?
- A *deferral option* giving us the right to decide *at the end of one year* instead of pre-committing now
- Suppose the cost of investment *goes up to £1,800* if we wait to decide. Draw the decision tree to illustrate this problem. Calculate the price of this option, i.e. the difference between the value of the project with the deferral option and its value given pre-commitment

Option Exercise

- If the price of the product turns out to be £300, the present value of the investment at that time is
  - £300 + £300/0.1 − £1800 = £1500.
- When discounted to the present at 10% and weighted by its 50% probability, the NPV of the project with the right to defer is £681.80; the price of the option is 681.8-545.5 = £136.3
- If the price turns out to be £100, you simply don't invest because the expected return of the project is
  - £100 + £100/0.1 - £1800 = -£700



(a) NPV assuming precommitment

(b) Value with the option to defer

Discussions on Real Options versus NPV

- Note that managers have been observed to accept negative NPV projects.
  - In the previous example, we can also calculate the NPV of £100 state: when discounted to the present at 10% and weighted by its 50% probability, this state contributes to -£318.2 to the NPV, leading the average NPV to be £363.6
- The main difference between NPV methodology and real options is that the former *discounts expected cashflows at a constant discount rate*. NPV implicitly assumes that no decisions will be made in the future— that all expected cashflows are pre-committed.
- A second important difference between NPV and real options is that they deal with *mutually exclusive opportunities* in quite different ways. NPV treats the decision to defer one year as a mutually exclusive alternative from deferring for two years and so on. The NPV of each possible deferral choice is calculated, and we then choose the maximum of the set. In contrast, real options analysis uses a decision tree and works backward through it, from the future to the present, to calculate a single value.

Seminar Problem 1 Q1

1. Irreversible investment

It costs a risk neutral firm £800 to set up a factory (fixed cost). The factory can produce one unit of output per year forever. The current price of a unit of output is £100. The product price is currently uncertain. In the next period the price will increase or decrease by 50% (with equal probability) and remain fixed forever at the level it has reached. The interest rate is 10%.

a) According to NPV, should the firm invest now? This means spending £800 in the current period and selling the first unit of output for £100 today and either £150 forever afterwards or £50 forever afterwards (with equal probability).

Seminar Problem 1 Q1

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a) According to NPV, should the firm invest now? This means spending £800 in the current period and selling the first unit of output for £100 today and either £150 forever afterwards or £50 forever afterwards (with equal probability).

The expected price of output is $0.5 * £150 + 0.5 * £50 = £100$

$$NPV = -£800 + \sum_{t=0}^{\infty} \frac{£100}{(1+10\%)^t} = -£800 + £1100 = £300 > 0$$

So the firm should invest now.

Seminar Problem 1 Q1

b) What is the real option value of waiting to see whether the price goes up or down? This means investing £800 next period and getting the appropriate price forever.

Seminar Problem 1 Q1

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Suppose the firm decides to wait and invest only once it knows the price.

If the price goes down, the firm won't invest; the future (period 1) value is

$$-£800 + \sum_{t=1}^{\infty} \frac{£50}{(1+10\%)^{t-1}} = -£800 + £550 = -£250 < 0$$

If the price goes up, the firm will invest; the future (period 1) value is

$$-£800 + \sum_{t=1}^{\infty} \frac{£150}{(1+10\%)^{t-1}} = -£800 + £1650 = £850 > 0$$

The expected present (period 0) value of waiting and the option value are

$$NPV = 0.5 * 0 + 0.5 * \frac{£850}{1.1} = £386.36$$
$$Option\ value = £386.36 - £300 = £86.36$$

Seminar Problem 1 Q1

c) If the price for deferred investment is higher (the firm has to invest £I > £800 at the beginning of next period) how high can it be before the firm will choose to invest now?

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First, work out whether the firm will invest if the price goes up or down

If the price goes down, the future (period 1) value of revenue is

$$\sum_{t=1}^{\infty} \frac{£50}{(1+10\%)^{t-1}} = £550$$

So the firm will invest after a price fall only if $I \leq £550$. If the price goes up, the future value of revenue is

$$\sum_{t=1}^{\infty} \frac{£150}{(1+10\%)^{t-1}} = £1650$$

So the firm will invest after a price rise only if $I \leq £1650$. If price is any larger, it will never invest tomorrow and will certainly invest today, but this ceiling price is too high. If the firm invests tomorrow only if price goes up, its *present* value of waiting is

$$0.5 * \left[\frac{-I}{1.1} + \sum_{t=1}^{\infty} \frac{£150}{(1+10\%)^{t}}\right] = 0.5 * \left[£1500 - \frac{I}{1.1}\right] = £750 - \frac{I}{2.2}$$

The firm will prefer to invest now if £300 exceeds this amount, i.e. $I \geq £990$.

Seminar Problem 1 Q1

d) How would your answers change if the firm could wait for two periods, and if the price could change at the end of period 1 and again at the end of 2 (in each case going up or down by 50% with equal probability) after which it would stay the same forever?

Seminar Problem 1 Q1

d) How would your answers change if the firm could wait for two periods, and if the price could change at the end of period 1 and again at the end of 2 (in each case going up or down by 50% with equal probability) after which it would stay the same forever?

This is a more complex problem, for you to think about as revision. The changes are;

- Price trajectories are different (up or down tomorrow and the next day)
  - Up, up gives prices: £100, £150, £225, £225…: PV=£2281
  - Up, down gives prices £100, £150, £75, £75…: PV=£918
  - Down, up gives prices £100, £50, $75, £75…: PV=£827
  - Down, Down gives prices £100, £50, £25, £25…: PV=£372
  - Expected present value of revenue is still £1100
- by waiting the firm has to discount the cost of investment and the resulting revenues twice. The optimal decision can be found by considering whether the firm would invest in period 2 if the price were £225 (yes, future value in period 2 = £1675), £75 (still yes, though FV is only £25) or £25 (no). The expected value of waiting (in period 0) is therefore

$$PVW = .25 * £1675 + .5 * £25 + .25 * £0 = \frac{£431.25}{(1.1)^2} = £356$$

So the value of this option = £356 − £300 = £56.

Seminar Problem 1 Q2

2. HS2 – a more complex option

The price of steel is currently $P_0 = £250$ per ton. Next year it will either increase by 50% to $P_g = £375$ or fall by 25% to $P_b = £187.50$ – these changes are equally likely, and the new price (and the plant) will last forever. Firm A is considering investing in a plant making steel girders for high-rise buildings. The investment must be made today or never, and will cost $I_0^A = £1.05\ billion$. The annual value of the project – starting in the period when the investment is made - is always $\mu = 175000$ times the price of steel. The risk free interest rate is $r_f = 5\%$.

a) Should the firm invest in the plant?

Seminar Problem 1 Q2

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a) Should the firm invest in the plant?

$NPV = \mu P_0 - I_0^A + \frac{0.5*\mu*(P_g + P_b)}{r_f} = -£21.875\ million$; the investment shouldn't be made.

Seminar Problem 1 Q2

b) Suppose that management has the option to expand the scale of the operation after one year. At that time, it can double the gross value of the project by investing an additional $I_1^A = £800\ million$. What is the value of this option? Should the firm invest in the smelter today?

Seminar Problem 1 Q2

b) Suppose that management has the option to expand the scale of the operation after one year. At that time, it can double the gross value of the project by investing an additional $I_1^A = £800\ million$. What is the value of this option? Should the firm invest in the smelter today?

The decision to make the first investment is taken at $t = 0$. The option must be agreed at $t = 0$ but exercised (expand or not) at $t = 1$. Expected annual revenue after this year is $R^E = 50\% * \mu * 2 * (P_g + P_b) = 49.22\ million = 50\% * 2(R_g + R_b)$.

If Up	If down	Formula	Value
No	No	$\mu P_0 - I_0^A + \frac{R^E}{r_f}$	-£21.875 m
Yes	No	$\mu P_0 - I_0^A + .5\left[\frac{2R_g - r_f I_1^A}{r_f(1+r_f)}\right]$	£253.42 m
No	Yes	$\mu P_0 - I_0^A + .5\left[\frac{2R_b - r_f I_1^A}{r_f(1+r_f)}\right]$	-£74.7 m
Yes	Yes	$\mu P_0 - I_0^A + \frac{2R^E - r_f I_1^A}{r_f(1+r_f)}$	£200.6 m

The investment should be undertaken. The value of the expansion option is the difference between the NPVs; £253.42 $million - 0$ as the project would not be pursued without this option.

Seminar Problem 1 Q2

Now suppose that Firm B has entered a partnership with a foreign steel producer who offers the following opportunity: Firm B can invest in a rail plant using the partner's steel for a current investment of $I_0 = £20\ million$, but must invest a further $I_1 = £85\ million$ next year. The value of the investment depends on whether the firm wins an HS2 contract - it will learn the outcome next year. If the firm wins the contract, the value of the plant will be $V^G = £7.5\ million$ per year from then on but if another firm wins the contract or HS2 is abandoned, the plant will only be worth $V^B = £3.25\ million$ £3.25 million per year. The firm assesses the chances of a successful bid for the HS2 contract at $\pi = 40\%$.

c) Should the firm invest in the plant?

Seminar Problem 1 Q2

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c) Should the firm invest in the plant?

$$PV(cost) = 20 + \frac{85}{1.05} = 100.9524$$
$$EPV(revenue) = \frac{.4 * 7.5 + .6 * 3.25}{0.05} = 99$$
$$ENPV = 99 - 111.9524 = -1.952380952$$

Or:

$$NPV = \frac{0.4 * £7.5m + 0.6 * £3.25m - 5\% * £85m}{5 * 1.05} - £30m = -£1.95\ million$$

This is negative, so the answer is again no.

Seminar Problem 1 Q2

Suppose that management has the option to abandon the project if its HS2 bid is unsuccessful, losing its initial investment but avoiding the further investment of £75 million.

d) Will the firm invest today, and what is the value of the option to abandon?

Seminar Problem 1 Q2

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Abandon If win	Abandon If lose	Formula	Value
No	No	$\frac{\pi V^G + (1-\pi)V^B}{r_f} - \frac{I_1}{1+r_f} - I_0$	£-1.95 m
No	Yes	$\pi\left(\frac{V^G}{r_f} - \frac{I_1}{1+r_f}\right) - I_0$	£7.62 m
Yes	No	$(1-\pi)\left(\frac{V^B}{r_f} - \frac{I_1}{1+r_f}\right) - I_0$	£-29.57 m
Yes	Yes	$-I_0$	£-20 m

The value of the optimal exercise of the option (£7.62 m) is the value of the option because the investment would not be made otherwise.