EC334 Topics in Financial Economics
First Seminar

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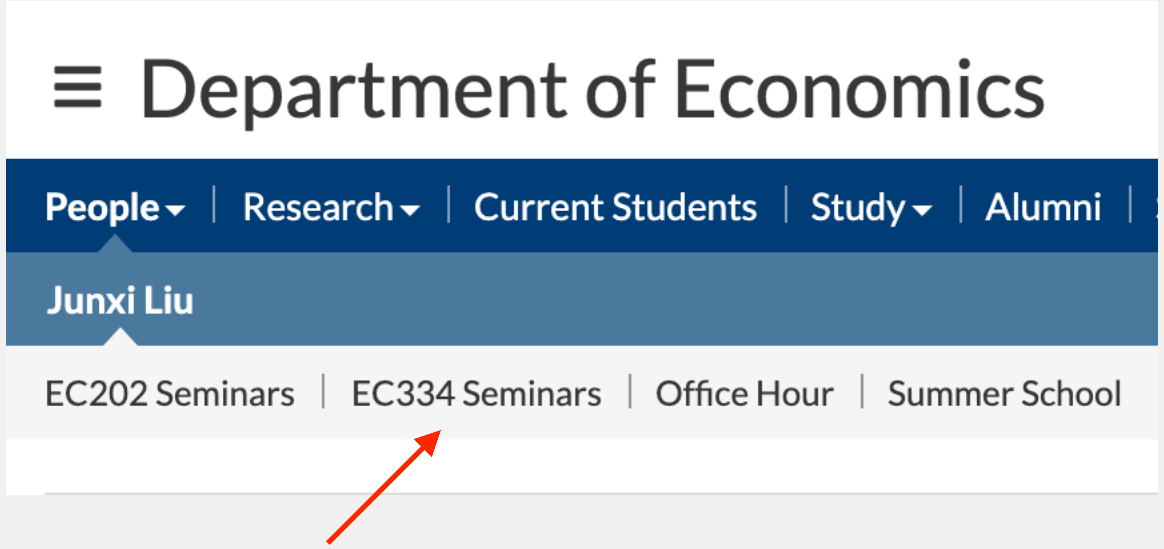
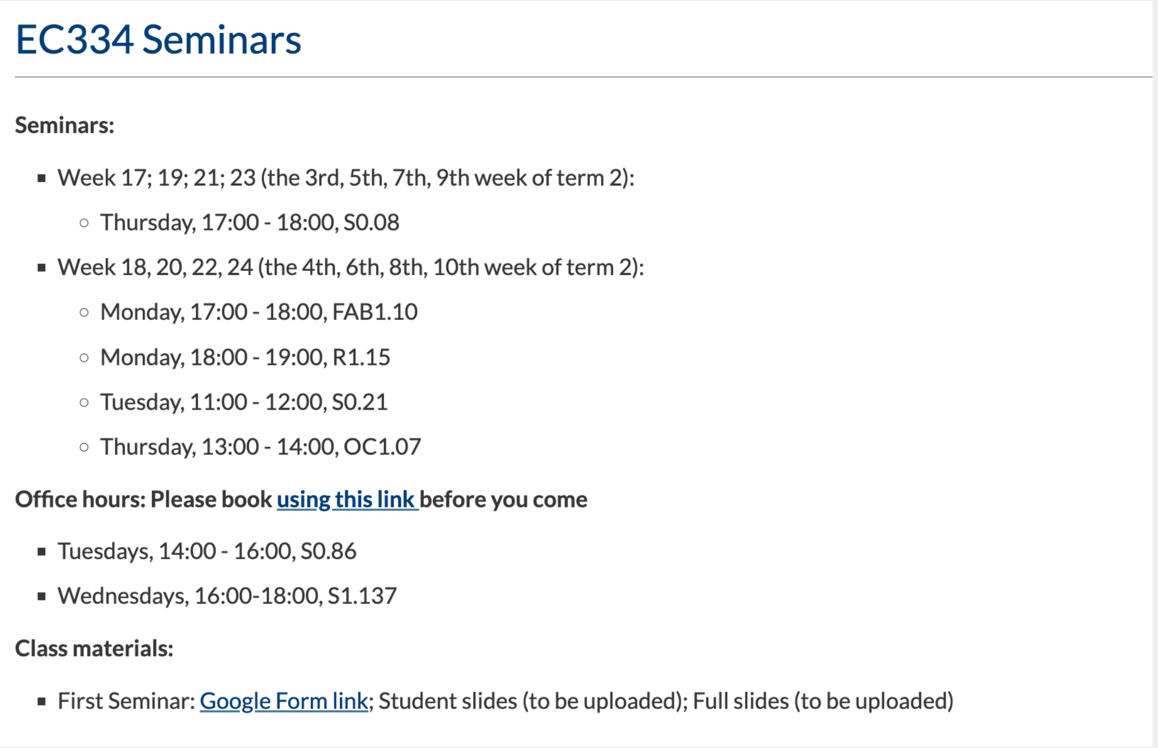
Welcome!

- I am Junxi Liu, a second-year MRes/PhD student in the department of economics
- There are a total of four seminar classes for EC334, one every two weeks, and each class will cover (roughly) two weeks' lecture material
- 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: junxiliu.com





EC334 Seminars

Seminars:

- Week 17; 19; 21; 23 (the 3rd, 5th, 7th, 9th week of term 2):
  - Thursday, 17:00 - 18:00, S0.08
- Week 18, 20, 22, 24 (the 4th, 6th, 8th, 10th week of term 2):
  - Monday, 17:00 - 18:00, FAB1.10
  - Monday, 18:00 - 19:00, R1.15
  - Tuesday, 11:00 - 12:00, S0.21
  - Thursday, 13:00 - 14:00, OC1.07

Office hours: Please book using this link before you come

- Tuesdays, 14:00 - 16:00, S0.86
- Wednesdays, 16:00-18:00, S1.137

Class materials:

- First Seminar: Google Form link; Student slides (to be uploaded); Full slides (to be uploaded)

- I will also send materials to you via email
- My office hours (week 4-10 of term 2):
  - Tuesdays, 14:00 - 16:00, S0.86
  - Wednesdays, 16:00-18:00, S1.137
  - Book on my website

More logistics…

- Every week, I will send you a Google Form link to get your impressions of difficulty and questions about the materials to be covered — please try to participate!
- In addition, I will ***not*** be printing slides for every one for environmental reasons. I encourage you to use digital versions of slides, which will be uploaded to my website and sent to you via email. If you do need printed versions of slides, you will need to indicate this in the Google Form
- 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 personal website.
  - If none of them suits you, please contact the UG office to mitigate your absence.

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

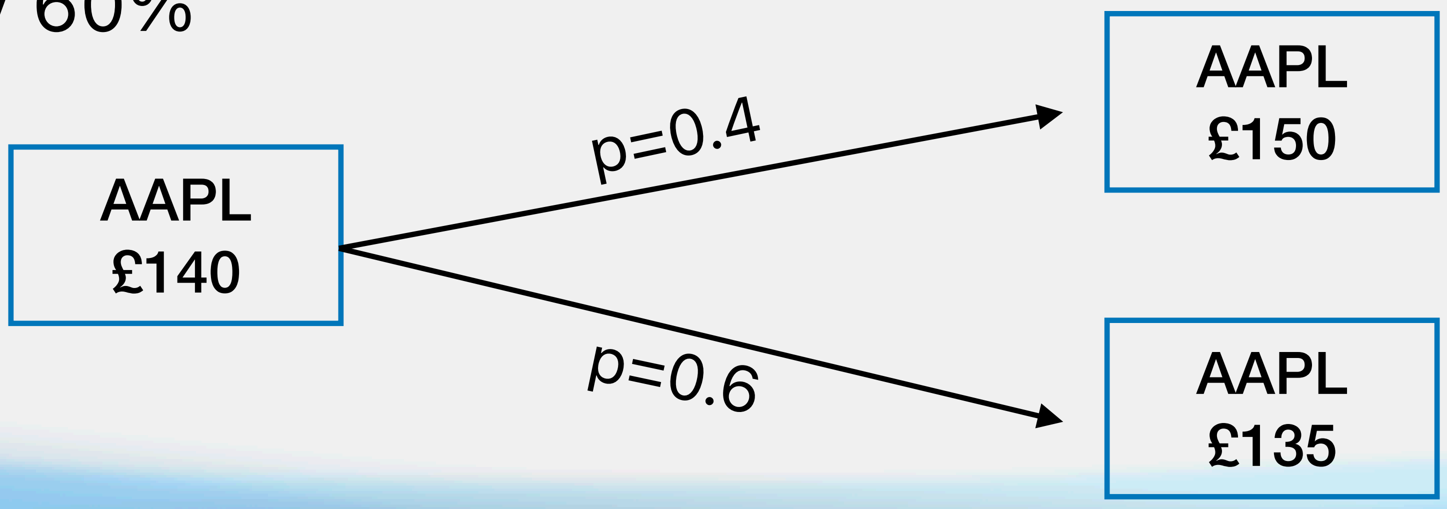
r = rate of return

n = number of periods

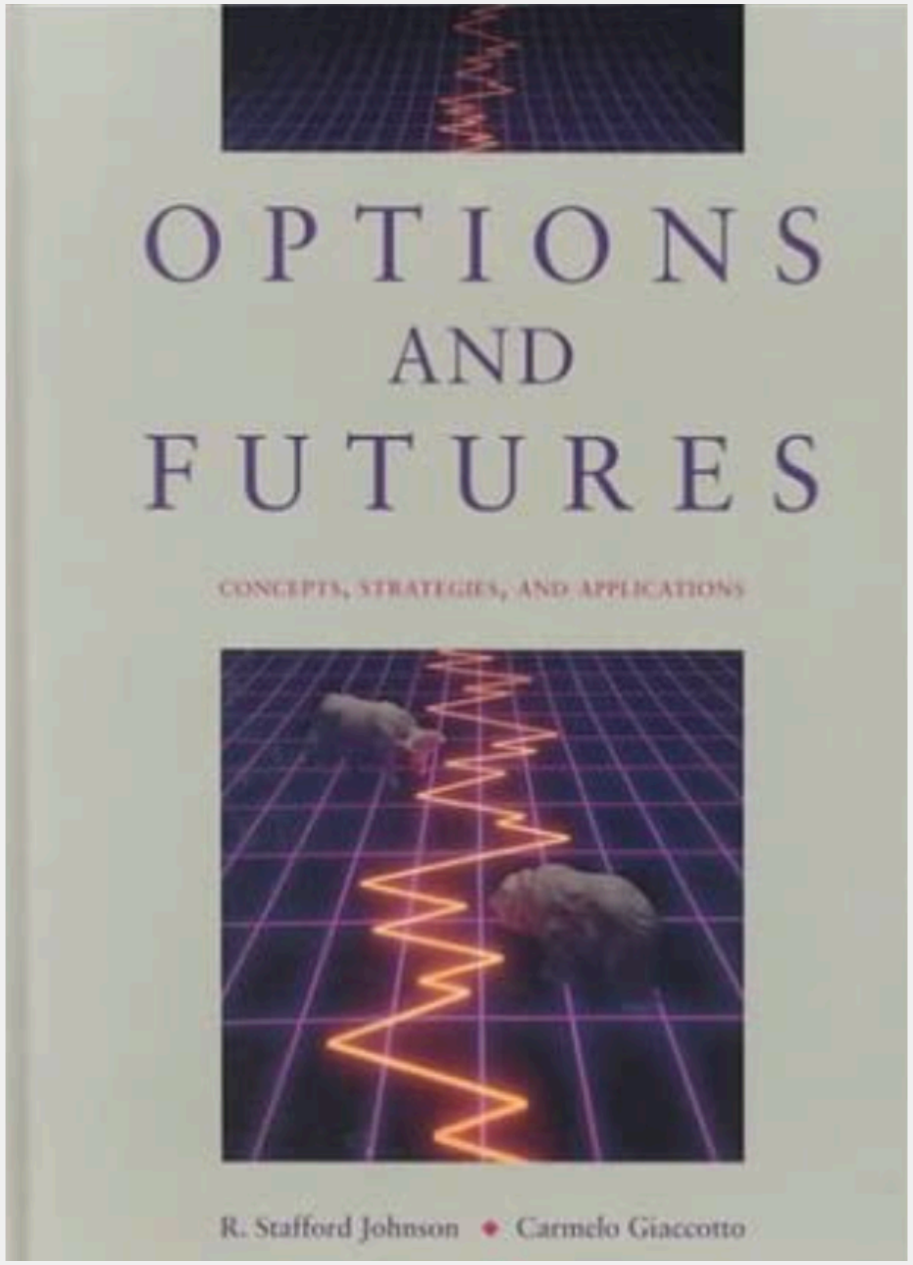
  - For example, if the risk-free interest is 5%, the present value of £1000 one year later will be 1000/1.05 = £952.38

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%

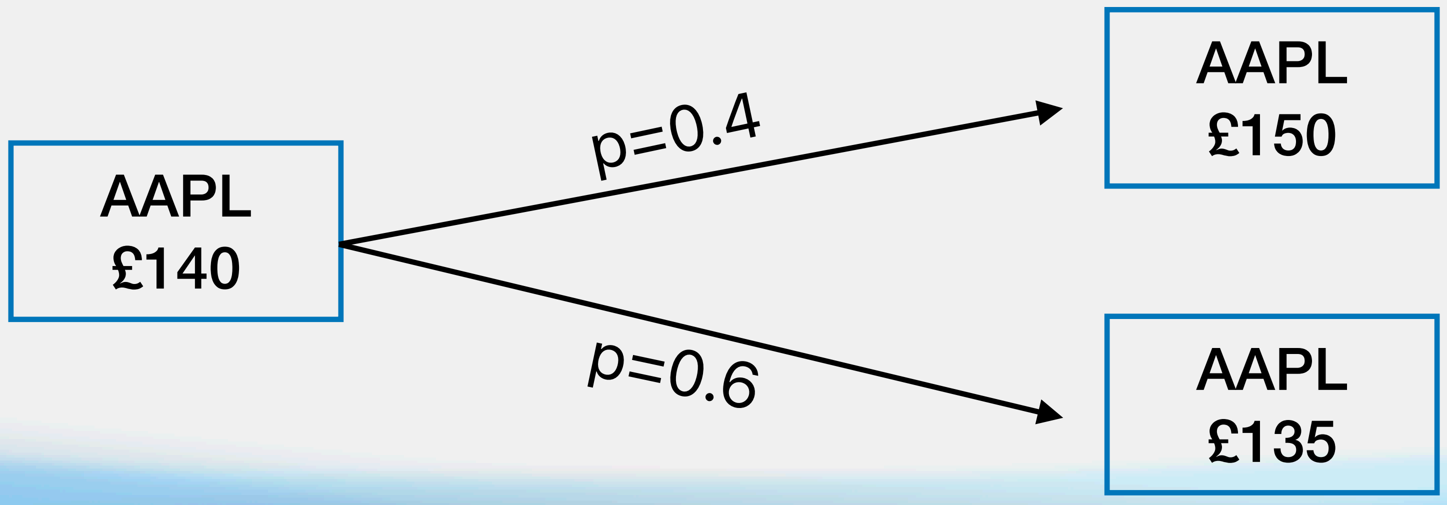


Options and "options"



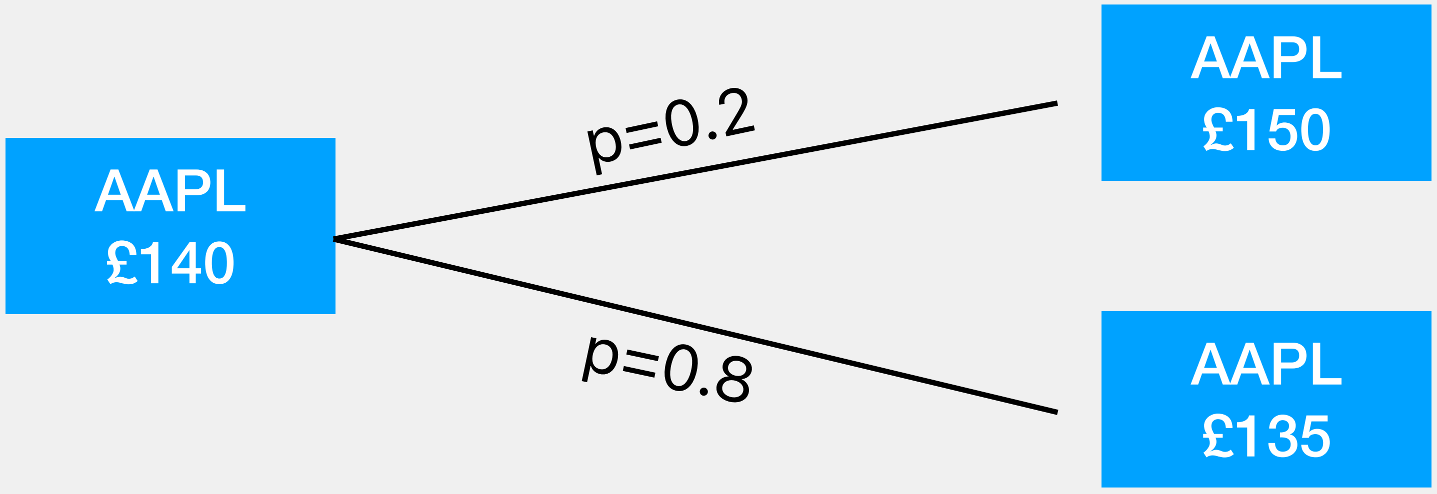
Introduction: options

- 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.
- Aristotle wrote a story about Thales (Born c. 626/623 BC, the guy who thinks water is the first principle and the Earth is a disk floating in an expanse of water)
  - One year ahead, Thales forecast the next olive harvest would be an exceptionally good one. As a poor philosopher, he did not have many financial resources at hand. But he used what he had to place a deposit on the local olive presses. As nobody knew for certain whether the harvest would be good or bad, Thales secured the rights to the presses at a relatively low rate. When the harvest proved to be good, and so demand for the presses was high, Thales charged a high price for their use and reaped a large profit.
  - Note that if the harvest is bad, Thales doesn't have to pay the presses for usage — option!

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

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

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

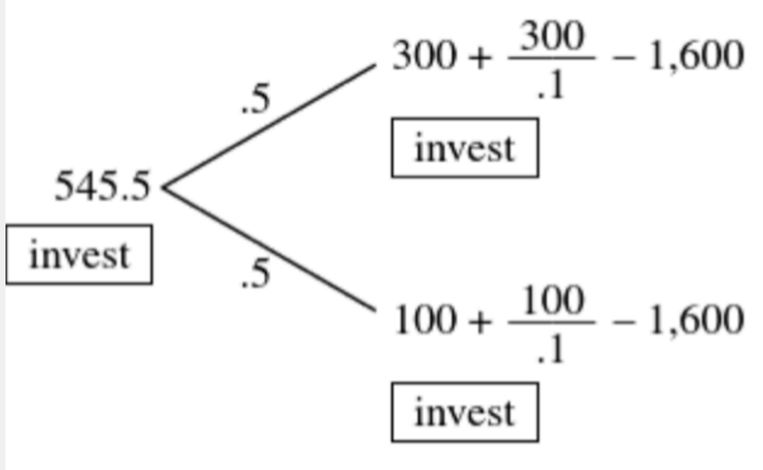
$$\text{NPV(one period)} = \frac{(-1600 + 0.5^{*}300 + 0.5^{*}100)}{1.1} = -1272.7$$

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

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

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

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



(a) NPV assuming precommitment

When $-1 < r < 1$

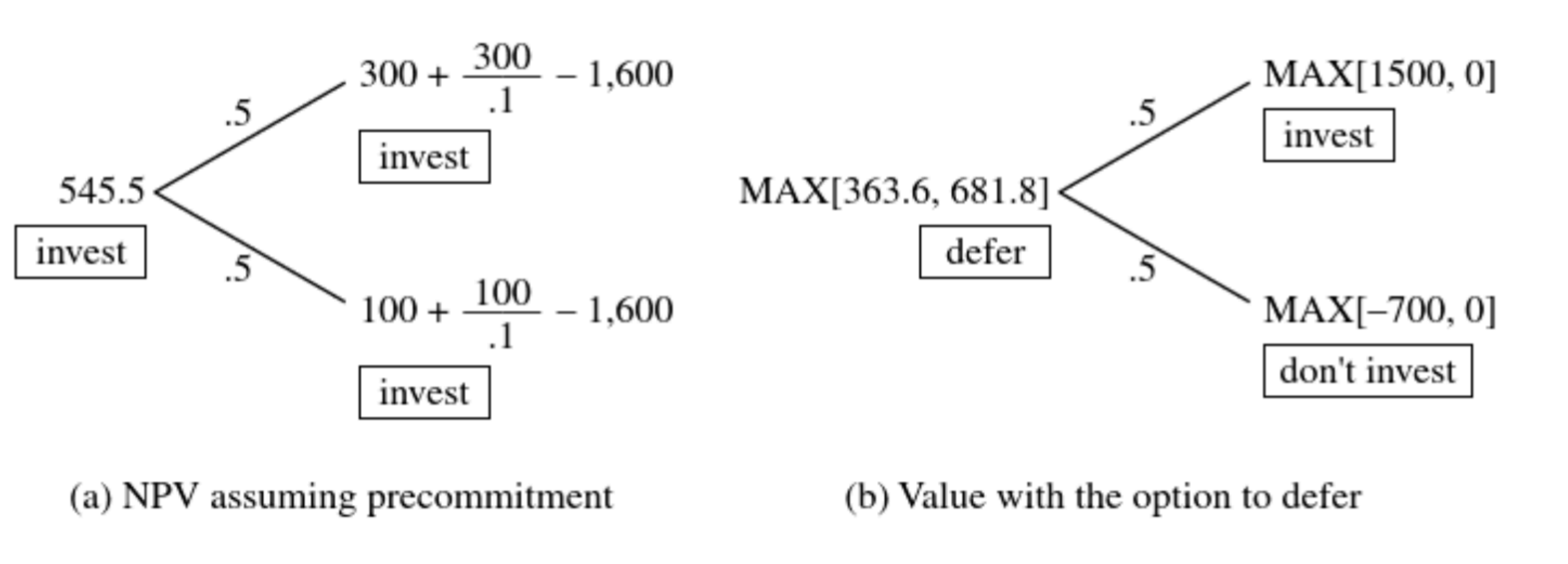
$$\lim_{n\to\infty} \sum_{k=1}^{n} a * r^k = \lim_{n\to\infty} a * \frac{r(1-r^n)}{1-r} = a * \frac{r}{1-r} = \frac{a}{\frac{1}{r} - 1}$$

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



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.

Discussions on Real Options versus Decision Trees

- They both make state-contingent future decisions
- Decision trees assume a constant discount rate — either the risk-free rate or the weighted average cost of capital—throughout the tree.
- Real options analysis uses replicating portfolios and obeys the law of one price. Implicitly, it changes the risk-adjusted discount rate at each branch in the tree.
- If we extend the simple one-period example given above to the two-period example, decision tree may face difficulty on choosing discount rate

Risk-neutral probabilities

The Risk Neutral Probability (p^{rn}) gives the same PV when we discount cash flows $(\overrightarrow{CF})$ using the risk-free discount rate (r_f) as discounted cash flows using the objective (real) probabilities $\left(p^{obj}\right)$ and discounting at the risk-adjusted rate (r_{RA}) :

$$PV\left(\overrightarrow{CF}, p^{rn}, r_f\right) = PV\left(\overrightarrow{CF}, p^{obj}, r_{RA}\right)$$

- Note: risk-neutral probabilities are not “real” probabilities; they don’t reflect the actual odds of any particular cash flow. They are simply another way of determining the project’s market value.

See an real example from 2021 Final Exam

A property developer is considering taking advantage of the current increase in people working from home. It believes that it is possible to create a block of 500 new 'personal distance' offices with high-speed interconnections and 'smart rooms' that will be attractive to employers once the pandemic threat recedes. The current estimate of the rental revenue per office unit per year is £41,250; The cost of servicing each office unit is £20,000 per year. The riskless rate of return – which is used by the project planners to discount all monetary flows - is 5%. If the project is undertaken this year, it will cost £67.5 million and generate revenue starting now. Once built, the offices are expected to generate the same annual costs and revenues forever.

a. What is the NPV if the project is undertaken now? (**10 marks**)

b. Now suppose that next year, when the current uncertainty is resolved, the rental revenue per unit per year is expected either to rise to £90,000 (the recovery state, with probability 25%) or to fall to £25,000 (the 'long Covid' state, probability 75%) – and to remain at that level forever. If the decision is delayed, the project cost will rise to £75 million in the recovery state or fall to £52 million in the long Covid state, but the annual servicing cost will remain at £20,000 per unit per year. What is the NPV if the project is delayed? (**15 marks)**

c. When (if at all) should the project be undertaken and what is the option to delay the project worth to the developer? (**10 marks**)

d. A university student living in the town points out that the project is risky (at least in the first year). How would you take this into account? (be as specific as you can clear about the method and the implications for valuing the option to delay) (**15 marks**)

a. What is the NPV if the project is undertaken now? (**10 marks**)

Say the original estimate is $R_0 = £41250 * 500$

$$NPV = \frac{(1+r)(Rev - MC)Q}{r} - cost = \frac{1.05(41.25K - 20K)500}{0.05} - £67.5m = £155.625m$$

b. Now suppose that next year, when the current uncertainty is resolved, the rental revenue per unit per year is expected either to rise to £90,000 (the recovery state, with probability 25%) or to fall to £25,000 (the 'long Covid' state, probability 75%) – and to remain at that level forever. If the decision is delayed, the project cost will rise to £75 million in the recovery state or fall to £52 million in the long Covid state, but the annual servicing cost will remain at £20,000 per unit per year. What is the NPV if the project is delayed? **(15 marks)**

The NPVs as seen from next period are

$$\frac{1.05 * (90K - 20K) * 500}{0.05} - £75m = £660m \text{ in the recovery state}$$

$$max\left\{0, \frac{1.05 * (25K - 20K) * 500}{0.05} - £52m\right\} = max\{0, £0.5m\} = £0.5m \text{ in long Covid}$$

So the NPV as seen from the present assuming optimal action is

$$\frac{25\% * £625m + 75\% * £0.5m}{1.05} = £157.5m$$

c. When (if at all) should the project be undertaken and what is the option to delay the project worth to the developer? (**10 marks**)

The project should be delayed but will be undertaken regardless of state; the value of the option to delay is worth $£157.5m - £155.625m = £1.875m.$

d. A university student living in the town points out that the project is risky (at least in the first year). How would you take this into account? (be as specific as you can clear about the method and the implications for valuing the option to delay) (**15 marks**)

The basic answer is to do one of two things. One is to compute the WACC for the decision tree (noting that the revenue streams after next period are riskless) using the objective probabilities and use the WACC to discount the NPVs used to value the project and the option. The other is to compute the risk-neutral probabilities for the original project and use these together with the riskless discount rate. This is worth 8 marks; a further 7 marks should be given for accurate calculations. The high revenue is $R_+ = £90000 * 500$; low revenue is $R_- = £25000 * 500$;

$$p^{RN} = \frac{(1 + r_f)R_0 - R_-}{R_+ - R_-} = \frac{(1 + 0.05) * 20625000 - 12500000}{45000000 - 12500000} = 28.17\%$$

$$NPV = \frac{p^{RN} * NPVH + (1 - p^{RN}) * NPVL}{1 + r_f} = £177.43m$$

Option value increases to $£177.43m - £155.625m = £21.8m$