Today

- Example of real option valuation
  - Simplico gold mine (Luenberger pp. 337, 341)
- Making the transition from financial options to real options
- Discussion of assumptions

Summary of key points about financial option pricing

- Observation from last lecture: If we price an option so as to align its expected return to existing expected returns in the market we allow for arbitrage
- Option pricing
  - Determining a portfolio of traded assets that has precisely the same payoffs as the option (replicating portfolio)
  - Price of the option is the market price of the replicating portfolio
  - Important: the uncertainty of option payoffs is deterministically (i.e. scenario-by-scenario), not only statistically, linked to the uncertainty of the payoffs of the replicating portfolio (payoffs depend on the SAME FLIP OF THE COIN)
  - Option price is the unique price that does not allow for arbitrage
  - Need the uncertain payoffs to be fully replicable in the market to be able to generate a replicating portfolio (this is called the spanning assumption)
- Real options: can we apply option pricing ideas to project valuation?
Some aspects of real project investments

- Partial irreversibility
  - sunk costs
- Multiple interdependent sources of uncertainty
  - market prices, technology, demand, etc.
- Abundant flexibility to react as uncertainties unfold
  - timing of investment, abandoning, growing, change product pricing, other marketing initiatives, etc.
- Strategic dimensions
  - market dominance, price maker, etc.

Surfing on the wave of fortune: Projects as options

- IMPORTANT CHANGE OF MINDSET: View project as an option to exploit future opportunities, if and when they arise
  - "No obligation"-feature: Can react to adverse unfolding of uncertainties (abandoning/down-sizing, etc.)
  - Reduce losses in case of adverse scenarios (analogue to no exercise if S<0K in the case of a European call option)
- Example:
  - Simplico gold mine (Luenberger p. 337): Lease is an option to extract gold if gold prices are high
    - No obligation: If gold prices are low, then we can shut down the mine
    - Additional flexibility: If gold prices are high then we can buy expansion equipment (Luenberger, p. 341)
- Let’s look at NPV vs. options analysis of the Simplico gold mine
  - open spreadsheet_sim.xls

Flexibility

- The value of a project, viewed as an option, lies in our ability to exploit beneficial scenarios (call) and to reduce losses in case of adverse scenarios (put)
- Flexibility in financial options:
  - call option - only exercise if stock price is high
  - put option - only exercise if stock price is low
- Flexibility in real options:
  - Real call option: flexibility to grow project if uncertainties are beneficial (high sales price, high demand, achievement of research aims, etc.)
  - Real put option: flexibility to shrink project if uncertainties are adverse (high material costs, low demand, etc.)
- Flexibility enables us to generate asymmetric payoff uncertainties from symmetric underlying uncertainties
Comparison of determinants of financial option and real option

<table>
<thead>
<tr>
<th>Financial option</th>
<th>Real option</th>
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<tbody>
<tr>
<td>Price of underlying asset (stock price)</td>
<td>“Value” of underlying uncertainties (e.g., price of gold, value of cash flows of non-flexible project)</td>
</tr>
<tr>
<td>Exercise price</td>
<td>Cost to carry out the real option</td>
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<tr>
<td>Time to expiration</td>
<td>Time by which the real option has to be carried out</td>
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<tr>
<td>Dividend payments</td>
<td>Production revenues that are not re-invested in the project</td>
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Discussion 1: Value

- The underlying uncertainty of a financial option – the stock price - is traded and therefore has a market value
- The underlying of a real option (project) is not necessarily traded and it may be very difficult to assign a value to the uncertainties
  - What’s the value of a research outcome (driving an R&D project) and how does it change over time?
- Proxies for values of uncertainties:
  - Value of uncertainties is the value of traded uncertainties (e.g., gold price, copper and zinc prices, etc.) – neglects non-traded uncertainties (e.g., research success, political uncertainty, etc.)
  - Value of underlying uncertainty is the market value (share price) of companies that deal primarily with these uncertainties
- The underlying uncertainty of a real option (project) is valued as share price index of a tech industry – neglects specific information, e.g., about research success or market success probabilities for a particular product

Discussion 2: Decisions

- Financial options have typically simple exercise decisions (yes/no)
- Real options have often complicated exercise decisions
  - Expand-shrink when and by how much?
  - Control production quantity over time
- Payoff of financial options at the time of exercise happens immediately and is certain
- Payoff of real option may be uncertain at time of exercise
  - Sometimes possible to lock in future uncertainties, e.g., raw material prices, through futures contracts
Conclusions

- The options paradigm is a powerful tool in project evaluation as it views projects as options to react to unfolding uncertainties.
- The analogy between financial options and real options is not simple – real options tend to be much more complicated.
  - In terms of valuing underlying uncertainties.
  - In terms of decisions.
  - In terms of longer time horizons and partial irreversibility of investments.
- There is the danger of being too simplistic when pressing a project valuation problem into a financial options frame.
  - Option valuation techniques add value to project valuation only if they are transparent to the decision maker.
  - Decision trees are a tool to make the value of flexibility transparent (next lecture).