Option Approach to
Capital Investment
&
Engineering Flexibility

Valuation

Project Description

- State-owned copper and zinc mine in Peru, 500km north of Lima
- Privatization in 1996: call for bids. Small upfront payment + promise to develop
- Little geological information
- Geological study would take two years, start after the bidding, end before construction
- Proceed with development if survey suggested the mine could be developed economically
**Project Description**

- **Bid & Explore (years 0-2)**
- **Develop: CapX (years 2-5)**
- **Produce Metal (year 5-closure)**
- **Close mine**
- **Walk away**

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**Sources of Uncertainty**

**Revenues**
- Mine’s life
- Future prices of zinc and copper
- Quantity of ore

**Costs**
- Operation expenses
- Capital Expenditures

**Uncertainty treatment**
- Deterministic (expected)
- Stochastic process (Year 0-2)
- Probability distributions
  - Monte Carlo simulation
Monte Carlo Numerical Simulation

1. Probability values for significant factors
2. Random selection of the factors according to their distribution
3. Determine result (NPV) for each combination
4. Repeat process and obtain NPV distribution

Sources of Uncertainty

- Price and quantity uncertainty prevails only during the first two years
- Price risk is assumed to be eliminated in year 2 by entering forward contracts to sell the output of the mine
- All other sources of uncertainty are modeled in the Monte Carlo simulation after year 2

→ Simulation result: Realization of expected NPV
Results: Base Case – No flexibility

10,000 Trials

Forecast: NPV (base case)

Frequency Chart

<table>
<thead>
<tr>
<th>Probability</th>
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</tr>
</thead>
<tbody>
<tr>
<td>$0.00</td>
<td>114.2</td>
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<td>$0.011</td>
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</table>

Mean = $556.85

Certainty is 75.61% from $0.00 to $6,015.64

Forecast: NPV (base case)

Mean = $550 million

Numerical Results: Option to Abandon

10,000 Trials

Forecast: NPV (base case)

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Mean = $819

Certainty is 75.61% from $0.00 to $6,015.64
Numerical Results: Option to Abandon

Option to abandon:
$819 - $550 = $269 million

Engineering Flexibility

- Add flexibility, add value?
- Starting engineering study earlier and faster would allow you to shorten construction to two years and ramp up production faster

What would you pay for this option?
Numerical Results: Early Development

Forecast: NPV (early development)

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<tr>
<td>Probability</td>
<td>$0.00 - $1.160.61</td>
</tr>
<tr>
<td>Mean = $567</td>
<td>$658.32</td>
</tr>
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10,000 Trials

Forecast: NPV (early development)

Mean = $567

Numerical Results:
Real Option for Early Development

Real Option (alone):
$567 - $550 = $17 million

- This real option would in fact be compounded with the option to abandon. Generally not additive!
Results: Early Development & Option to Abandon

Value of the Option: $836 - $820 = $16 million
References


Suggestions for further readings and references:

Note

This presentation was prepared as a basis for class discussion to illustrate the use of real option after the case developed by Professor Peter Tufano and Lecturer Alberto Moel from the Harvard Business School. This presentation contains simplifications. The figures that appear in this presentation reflect the opinion and assumptions of the authors of this presentation about the treatment of uncertainty and the cash flows projection. These figures differ from the one presented by Professor Peter Tufano and Lecturer Alberto Moel.