Valuation with Simulation of Options “on” and “in” a System

Capital Investment and Engineering Flexibility in the development of the Antamina mine (Peru)

Note

This presentation is based on the case developed by Peter Tufano and Alberto Moel from the Harvard Business School.

It contains simplifications. The figures appearing here differ from those presented by Tufano and Moel. They reflect the assumptions of the authors of this presentation about the treatment of uncertainty and the cash flows projection.
Project Description: Antamina

- State-owned copper and zinc mine in Peru, ~480km (300 miles) north of Lima
- Privatization in 1996: call for bids. Small upfront payment + promise to develop
- Little reliable geological information
- Geological study to take two years, start after the bidding, be available before construction
- Proceed with development if survey suggested the mine could be developed economically

Project Time Line

- Bid & Win
- Explore (years 0-2)
- Year 2
- Walk away
- Develop: CapX (years 2-5)
- Produce Metal (year 5-closure)
- Close mine
- Walk away
Sources of Uncertainty

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

Costs
- Operation expenses
- Capital Expenditures

Uncertainty treatment
- Deterministic
- Stochastic process (Lattice, Years 0-2)
- Probability distributions
  Monte Carlo simulation

Monte Carlo Simulation

1. Probability values for significant factors
2. Random selection of factors according to their pdf
3. Determine 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 Options

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Forecast: NPV (base case)
10,000 Trials

Frequency Chart

Mean = $550 M
Simulation Results: Option to Abandon

Forecast: NPV (base case)

<table>
<thead>
<tr>
<th>Probability</th>
<th>Frequency Chart</th>
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<td>Mean = $819</td>
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Certainty is 75.61% from $0.00 to $6,015.64

Valuation: 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?

Simulation Results: Early Development

Forecast: NPV (early development)

Mean = $567
Valuation: Option for Early Development

Early Development Option (alone):
$567 - $550 = $17 million
Would easily justify several million $
spent early on design work

This real option would in fact be
compounded with the option to abandon
Generally not additive!

Simulation Results: Both Options

Forecast: NPV (early development)
10,000 Trials
Frequency Chart

Certainty is 76.09% from $0.00 to $5,926.22
Mean = $836
Valuation: Both Options Together

Value of both Options together:
$ 836 - $550 = $286 million

Incremental Value of Early Development Option:
$ 836 - $819 = $17 million

Appears additive, but actually a difference.
In this case rounded out and insignificant

References

