

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

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

Note

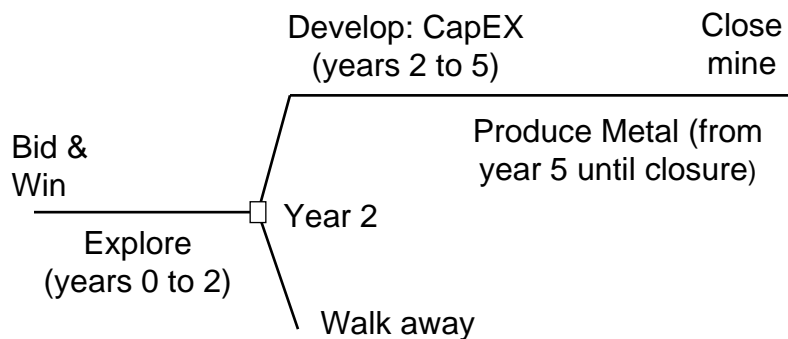
This presentation is based on the case developed by Peter Tufano and Alberto Moel from the Harvard Business School.

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.

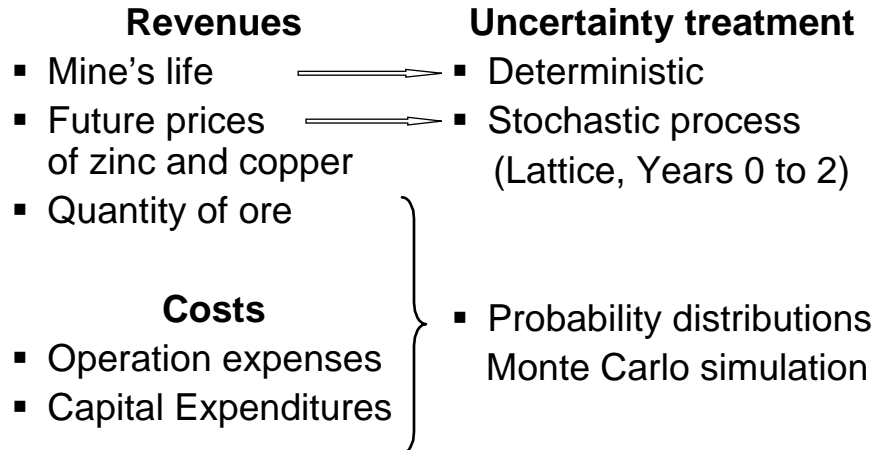
Project Description: Antamina

- State-owned copper and zinc mine in Peru, ~480km (300miles) 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

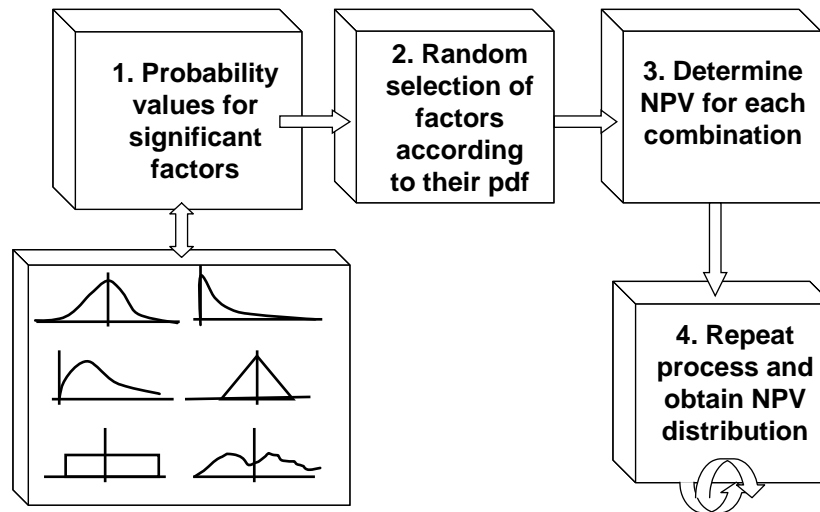
Project Time Line



Sources of Uncertainty



Monte Carlo Simulation

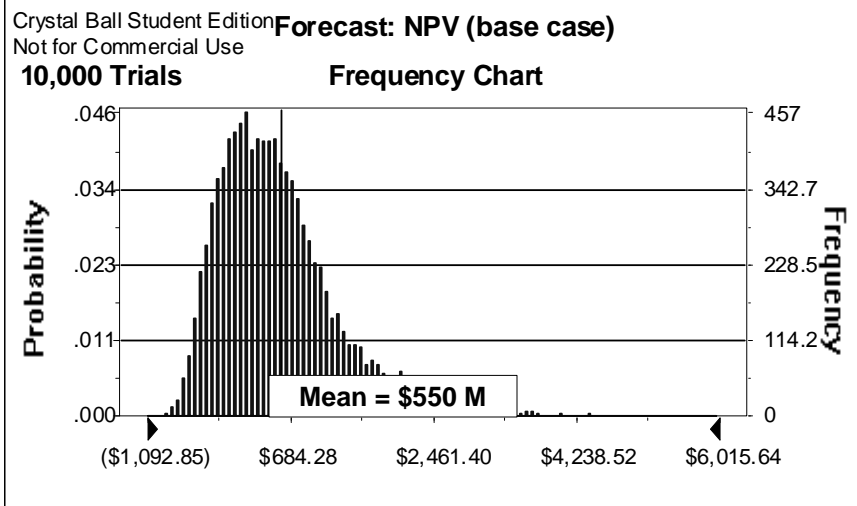


Sources of Uncertainty

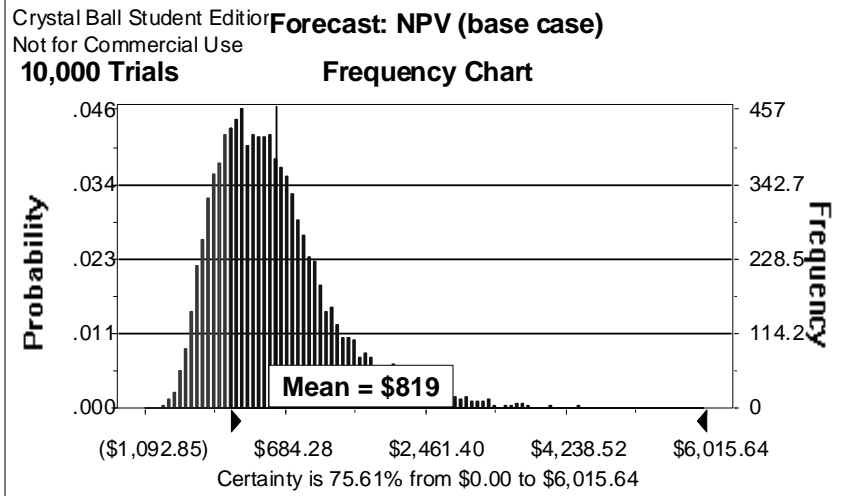
- Price and quantity uncertainty prevails only during the first two years
- Price risk is assumed to be eliminated in year 2 by entering forward contracts to sell the output of the mine (this is assumption M&T made – a bit of a stretch...)
- All other sources of uncertainty are modeled in the Monte Carlo simulation after year 2

⇒ Simulation result: Realization of expected NPV

Results: Base Case – No Options



Simulation Results: Option to Abandon



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Valuation: Option to Abandon

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

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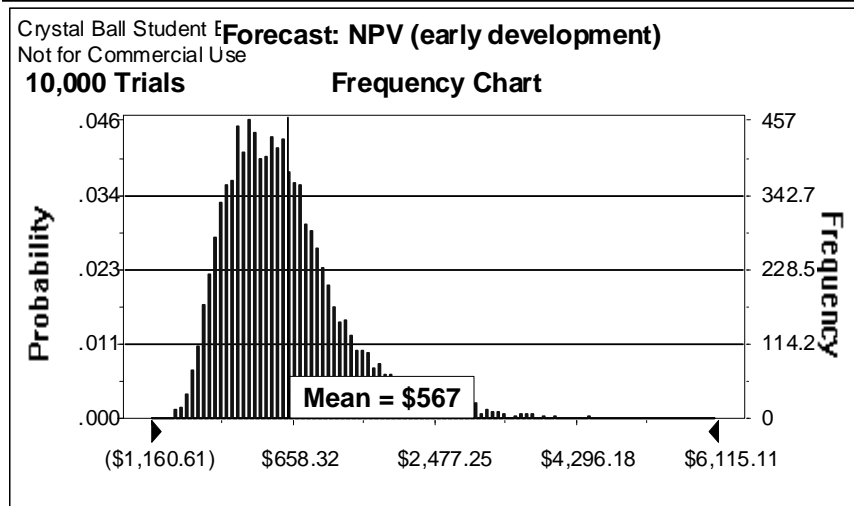
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Engineering Flexibility

- 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



Valuation: Option for Early Development

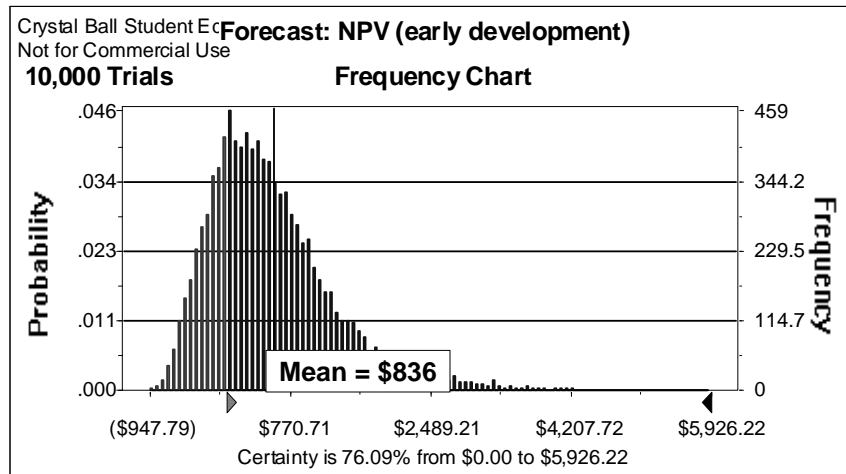
Early Development Option (alone):

$$\$567 - \$550 = \$17 \text{ million}$$

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



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

- Tufano, P., Moel, A., (1997) "Bidding for Antamina", Harvard Business School Case number 9-297-054, Rev. Sept. 15.
- Tufano, P., Moel, A., (2000) "Bidding for the Antamina Mine – Valuation and Incentives in a Real Option Context", in "Project Flexibility, Agency, and Competition," edited by Brennan, M. and Trigeorgis, L., Oxford University Press
- Hertz, D. (1979) "Risk Analysis in Capital Investment", Harvard Business Review September-October, pp. 169-180