Employee stock option valuation with an early exercise boundary

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Employee Stock Option Valuation

Black & Scholes model

vs.

Binomial Lattice models

Hull & White (2004, FAJ)

Brisley & Anderson (2008, FAJ)
ESO valuation: Why do we care?

• Accounting profits/disclosures/analyses
  – Black/Scholes permitted, Lattice models preferred

• Real compensation decisions
  – Interpreting competitive peer group data
  – Determining option awards
    • ‘$ per option’ estimate may affect ‘number granted’
      e.g. “$1 million option award”
        @ estimated $4/option → 250,000 options
        @ estimated $5/option → 200,000 options
  – Managing the optics
Employee Stock Option

Before vesting: No exercise

After vesting: voluntary early exercise permitted

Quit → forfeiture

Quit → forced early exercise

Quit → forfeiture
Black/Scholes for ESOs

- *Ignores* all vesting conditions (time & perf.)
- Combines all experience/estimates of quitting and voluntary early exercise into a single estimate of ‘Expected Life’.

**Example:**
- initial stock price $10; strike price $10
- interest rate 5%p.a.; volatility 40%p.a.
- maturity 10 years; expected life?
Black & Scholes, ESO prices

- Expected life "4 yrs" $3.82
- Expected life "8 yrs" $5.43

Graph showing stock price over time with maturity as a parameter.
Binomial Lattice (binomial ‘tree’)

- Can handle vesting conditions (time & perf.)
- Can treat separately the estimates of
  - quitting
  - voluntary early exercise
- Example: (maturity 10 years)
  - initial stock price $10; strike price $10;
  - interest rate 5%p.a.; volatility = 40%p.a.
  - Quit rate? Voluntary early exercise policy?
Hull & White (2004, *FAJ*): quit probabilities; vesting; voluntary exercise when stock reaches *fixed* multiple of strike price
Hull/White: voluntary exercise if stock reaches fixed multiple of strike price

Stock price

$30

$20

$10

0

vesting date

10 yrs maturity

Quit → forfeiture

Quit → forfeiture

Voluntary exercise boundary
Hull/White: ESO prices

Stock price

$25

$20

$15

$10

vesting date

“2.5-times strike”
gives $5.09

“1.5-times strike”
gives $3.85

10 yrs maturity

10 yrs
Early exercise ‘policy’

- Black/Scholes assumes employees exercise at some target *date* (whether in-the-money by $0.01 or by $100.00...).
  - ‘Vertical’ exercise boundary
  - Assumes employees ignore option time value...
- Hull / White assumes employees exercise at some target *stock price* (whether achieved very early in option life or very late).
  - ‘Horizontal’ exercise boundary.
  - Assumes employees ignore option time value...
Bettis et al. (2005):

• Employees require *high* stock price to induce exercise *early* in option life.
• But willing to exercise at *lower* stock prices *later* in option life
• Employees exercising early typically capture 80%-90% of the *remaining* option value. And this statistic is relatively stable whether stock prices grew fast or slow.
Early exercise ‘policy’

• Brisley/Anderson assumes employees exercise early when they can achieve some target *fixed percentage* of the *remaining* option value.
  – Assumes employees trade-off *intrinsic value* (moneyness) captured vs. *time value* forgone
  – Gives ‘Downward sloping’ exercise boundary
Brisley/Anderson (2008, FAJ): quitting; vesting; voluntary exercise at fixed % of remaining option value
Brisley/Anderson (2008): voluntary exercise at fixed % of remaining option value

Voluntary exercise boundary

Quit → forfeiture

Stock price

$25

$20

$15

$10

0

vesting date

10 yrs maturity

Quit → forfeiture

Quit → forfeiture
Brisley/Anderson (2008), ESO prices

- "90%" gives $5.42
- "80%" gives $4.82
- "70%" gives $4.21
Brisley/Anderson (2008 *FAJ*)

- We offer a new lattice model for valuing ESOs
  - Straightforward and intuitive
  - Approximates better the real exercise decisions of employees
- B/A option prices can be lower or higher than B/S or H/W prices. But we show why our model is more ‘stable’ – the $ price outputs are less *sensitive* or vulnerable to unusual historical exercise data from firms with atypical stock price histories.
Estimating the inputs

- “…assumptions, such as the employees’ expected exercise behavior, may be derived from the entity’s own historical experience…” [FAS123R]

Black/Scholes: time to exercise

Hull/White: stock price (multiple of strike) at exercise

Brisley/Anderson: percentage of remaining option value captured at exercise
Employees require *high* stock price to induce exercise *early* in the life, but *lower* stock price to exercise *later on*.
Black/Scholes: prior experience of option lives may depend on stock price history...

- Expected life “4 yrs”:
  - $3.82

- Expected life “8 yrs”:
  - $5.43
Hull/White: prior experience of ‘exercise multiple’ may depend on stock price history…
Brisley/Anderson (2008), prior experience of ‘% option value captured’ is less sensitive to stock price history…
Takeaway on ESO valuation:
vesting + quitting + voluntary early exercise

Black/Scholes model, ‘expected life’

vs.

Binomial Lattice models

Hull & White (2004, FAJ)
Brisley & Anderson (2008, FAJ)

• stock price histories affect past early exercise behaviours. Affects $$-valuations…

• choice of model affects $$-valuations…