Fair Valuation of Employee Stock Options

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ABSTRACT

Current and proposed accounting standards, both national and international, suggest that the value of employee stock options should be estimated fairly, and recorded as expense in corporate financial statements.

Since these options are rather different from stock options that are traded on exchanges (for example, they are subject to vesting and forfeiture rules, may remain alive for as long as fifteen years, and cannot be traded), their valuation calls for non-standard methods. In addition, the patterns of forfeiture and early exercise that are observed empirically also should play a role in their fair valuation.

In this presentation, we review the approach that we have been developing at General Electric to value options awarded to employees, with emphasis on its components that involve probabilistic modeling and statistical data analysis.

ORIENTATION

PROBLEM How to estimate the value employee stock options fairly

CONCEPTS & ISSUES Differences between employee stock options and exchange-traded options

HISTORICAL DATA Fifty years of history of GE grants

VALUATION PROCEDURES

GE FASB123	Generalized binomial lattice model for American calls
MONTE CARLO	Simulation procedure that incorporates all relevant differences between ESOs and ETOs
MARS	Empirical model built from historical data

STOCK OPTIONS

Contracts that give their holders a right to buy (*call*) or sell (*put*) an underlying security for a given (*exercise*, or *strike*) price, on or before some specified *expiration* (or, *maturity*) date

- Typically, the holder of an option will pay the writer a fee (*premium*) for the contract
- *American* options may be exercised at any time up until they expire, while *European* options can be exercised only at expiration
- *Chicago Board Options Exchange:* About 1 million options on about 1,500 different stocks traded per day

EMPLOYEE STOCK OPTIONS (ESOs)

Granted by a company at no cost to the employees they are granted to

- Generally expire either when the employee leaves the company, or when they reach maturity, whichever occurs first
- Can be exercised only after they have vested, on any trading day until they expire
- Cannot be traded: must be exercised by expiration date (and only when *in the money*), else expire worthless
- Usually are issued *at the money*: strike price equal to stock price on grant date

EMPLOYEE STOCK OPTIONS — VIEWPOINTS

- Zvi Bodie, Robert Kaplan, & Robert Merton

  For the Last Time: Stock Options Are an Expense

  Harvard Business Review — March, 2003

- David Leonhardt

  The Complicated Calculus of Stock Options

  The New York Times — March 30th, 2003

EMPLOYEE STOCK OPTIONS — VIEWPOINTS

- *Transfers of value do not have to involve transfers of cash*

  In general, an instrument's lack of liquidity will reduce its value to the holder. But the holder's liquidity loss makes no difference to what it costs the issuer to create the instrument

  — Bodie, Kaplan, & Merton (2003)

- *If Cisco Systems had made financial assumptions like the ones used by similar companies, it would have lost money last year after accounting for options, rather than appearing to earn 5 cents a share*

  — Leonhardt (2003)

FAIR VALUATION OF EMPLOYEE STOCK OPTIONS

- ESOs have value when granted,
  and their fair value can be estimated

DIFFERENCES BETWEEN EXCHANGED-TRADED OPTIONS (ETOs) AND ESOs

- Maturity
- Non-Transferability
- Dilution
- Vesting Restrictions
- Forfeiture & Forced Early Exercise
- Corporate Taxation
- Employee Compensation, Stimulation & Retention

CONVENTIONAL VALUATION

- ESOs used to be assigned zero value when granted
- Proposed *financial accounting standards* recognize value at grant date, and mandate that such value be accounted for in corporate books

  Motivated by increasing scrutiny of corporate finances by shareholders, regulating boards, government agencies, and the public at large

- Several companies, including Boeing, Coca-Cola, and General Electric have, in the meantime, began expensing options voluntarily, using models that have traditionally been used to value ETOs (Black-Scholes formula, for example), and modifications thereof

TIERED APPROACH TO FAIR VALUATION

❶ Introduce minimal modifications to conventional valuation technology — *motivated by GE's particular vesting rules, and historical experience with optionees* — aligned with FASB 123

- Effective lifetime after vesting
- Forfeiture throughout vesting period
- Vesting restriction on early exercise

❷ Build consensus, and keep the regulatory door open to alternative valuation methods — *valuing ESOs is an active research area*

❸ Develop full simulation-based valuation engine that models all relevant factors that determine fair value

American Call on Dividends−Paying Stock

BINOMIAL TREE

At each node:
Upper value = Stock price
Lower value = Option price
Red option prices indicate exercise
Green option prices indicate holding
Maturity = 0.5 years
Strike price = 40
Interest rate = 9% per year
Volatility = 30% per year
Number of steps = 5
Time step = 0.1 years

Epoch (Years)					
0	40.00 **3.85**	43.89 **5.91**	47.67 **8.83**	52.37 **12.73**	57.54 **17.54**
0.1		36.48 **1.65**	39.52 **2.81**	43.40 **4.70**	47.68 **7.68**
0.2			32.77 **0.41**	35.99 **0.78**	39.53 **1.51**
0.3				29.85 **0.00**	32.78 **0.00**
0.4					27.20 **0.00**
0.5					24.29 **0.00**

					62.71 **22.71**
				57.54 **17.54**	
			52.37 **12.73**		51.87 **11.87**
		47.67 **8.83**		47.68 **7.68**	
	43.89 **5.91**		43.40 **4.70**		42.91 **2.91**
40.00 **3.85**		39.52 **2.81**		39.53 **1.51**	
	36.48 **1.65**		35.99 **0.78**		35.49 **0.00**
		32.77 **0.41**		32.78 **0.00**	
			29.85 **0.00**		29.36 **0.00**
				27.20 **0.00**	
					24.29 **0.00**

Dividend Epochs: 0.17, 0.42
Dividend Amounts: 0.5, 0.5

Call's Present Fair Price = 3.85

BINOMIAL TREE WITH VESTING RESTRICTIONS

American Call on Dividends−Paying Stock

Vesting at 0.15 Years

At each node:
Upper value = Stock price
Lower value = Option price
Red option prices indicate exercise
Green option prices indicate holding
Maturity = 0.5 years
Strike price = 40
Interest rate = 9% per year
Volatility = 30% per year
Number of steps = 5
Time step = 0.1 years

Epoch (Years)	0	0.1	0.2	0.3	0.4	0.5
						62.71
						22.71
					57.54	
					17.54	
				52.37		51.87
				12.73		**11.87**
			47.67		47.68	
			8.83		**7.68**	
		43.89		43.40		42.91
		5.91		**4.70**		**2.91**
	40.00		39.52		39.53	
	3.85		**2.81**		**1.51**	
		36.48		35.99		35.49
		1.65		**0.78**		**0.00**
	0		32.77		32.78	
			0.41		**0.00**	
				29.85		29.36
				0.00		**0.00**
					27.20	
					0.00	
						24.29
						0.00

Dividend Epochs: 0.17, 0.42
Dividend Amounts: 0.5, 0.5

Call's Present Fair Price = 3.85

American Call on Dividends−Paying Stock

Vesting at 0.45 Years

At each node:
Upper value = Stock price
Lower value = Option price
Red option prices indicate exercise
Green option prices indicate holding
Maturity = 0.5 years
Strike price = 40
Interest rate = 9% per year
Volatility = 30% per year
Number of steps = 5
Time step = 0.1 years

Epoch (Years)	0	0.1	0.2	0.3	0.4	0.5
						62.71
						22.71
					57.54	
					17.40	
				52.37		51.87
				12.59		**11.87**
			47.67		47.68	
			8.72		**7.54**	
		43.89		43.40		42.91
		5.83		**4.63**		**2.91**
	40.00		39.52		39.53	
	3.80		**2.77**		**1.51**	
		36.48		35.99		35.49
		1.63		**0.78**		**0.00**
	0		32.77		32.78	
			0.41		**0.00**	
				29.85		29.36
				0.00		**0.00**
					27.20	
					0.00	
						24.29
						0.00

Dividend Epochs: 0.17, 0.42
Dividend Amounts: 0.5, 0.5

Call's Present Fair Price = 3.80

EXAMPLE — Grant Valuation

Stock Price	*$25*	Vesting Epochs	*3, 5 years*
Strike Price	*$25*	Exp. Life after Vesting	*3 years*
Volatility of Stock Price	*30% per year*	Vesting Percentages	*50%, 50%*
Option's Lifetime	*10 years*	Dividend Epochs	*1¼, 2¼, …, 9¼ years*
Forfeiture Rate	*5% per year*	Dividend Yields	*2% per year*

Discount Rates

¼	*3%*	*½*	*3.5%*	*1*	*4%*	*2*	*5%*	*3*	*5.25%*
5	*5.5%*	*7*	*5.75%*	*10*	*6%*	*30*	*7%*		

Black-Scholes (Full Maturity, w/ Dividends)	**$8.74**
Black-Scholes (Eff. Maturity, w/ Dividends)	**$6.95**
GE FASB123	**$5.94**

For annual forfeiture rates between 0% and 10%,
GE FASB123 valuation ranges from $7.31 to $4.79

GE FASB123 PROCEDURE

- Value options that vest at different epochs separately, and then combine valuations via weighted average

- For each vesting epoch:

  - MATURITY: Vesting period + Expected lifetime after vesting

    Captures those features of early exercise that are summarized in this expected lifetime

  - VALUATION: Binomial tree for American call

    Modified to incorporate vesting restriction on early exercise

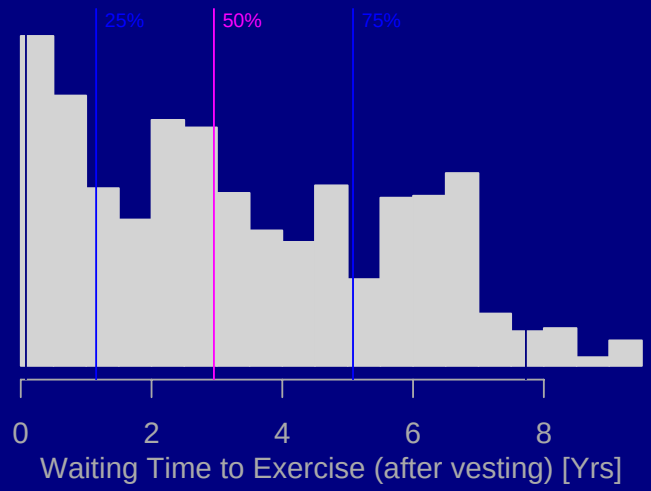
  - FORFEITURE: Compound forfeiture rate over vesting period

GE GRANTS — HISTORICAL DATA

FOCUS: Non-qualified grants — 80% of options granted 1955–2003

WAITING TIME TO EXERCISE: Probability distribution, of waiting time after vesting until exercise, estimated from historical data

	Yrs
5%	0.12
25%	1.09
50%	2.63
75%	4.72
95%	7.50



FORFEITURE RATE: Historical average for expired grants $\approx 5\%$ per year

VALUATION CHOICES — VIEWPOINTS

- *There is no standard method for arriving at these estimates, …Even the volatility assumption itself appears to be volatile*
  — Leonhardt (2003)

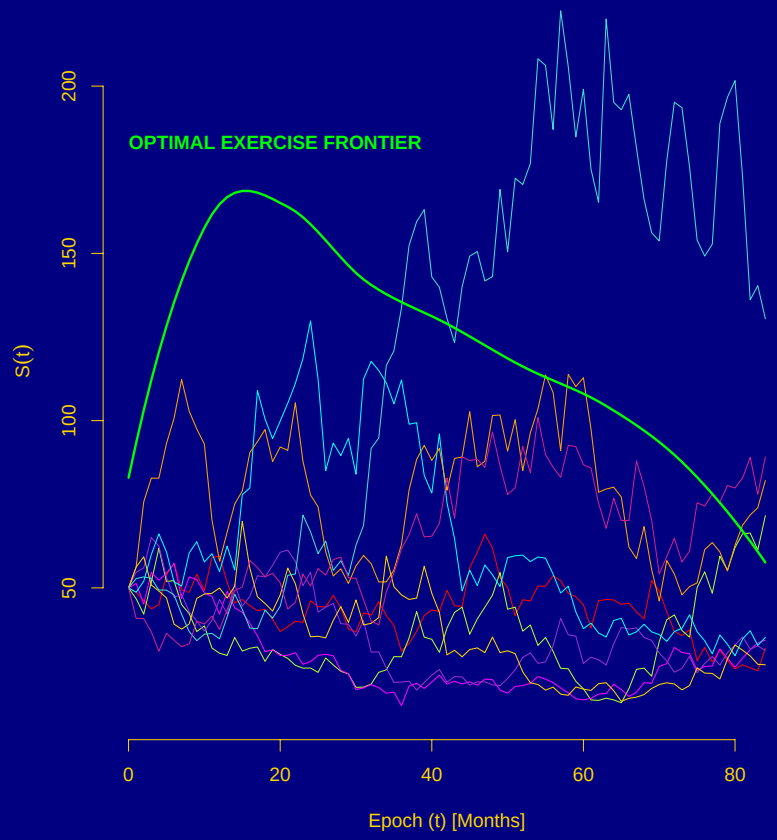
- *Many of these variables are difficult to estimate. Indeed, a firm seeking to overvalue its options might report values almost double those reported by an otherwise similar firm seeking to undervalue its options* — Mark Rubinstein (1995, Journal of Derivatives)

- *If companies were to mark compensation expense downward when employees forfeit their options, should they not also mark it up when the share price rises?* — Bodie, Kaplan, & Merton (2003)

MONTE CARLO SIMULATION

APPROACH: Monte Carlo simulation approach based on geometrical relation between stock price sample paths and optimal exercise frontier, and including:

- Vesting restrictions
- Uncertainty about early exercise
- Jump-diffusion model with stochastic volatility for temporal evolution of stock prices



EMPIRICAL VALUATION MODEL

Adaptive, non-linear (MARS) regression model

$v = (1 - \lambda)\exp\{f(K, B, \sigma, G, r, L)\}$

INPUTS

- K = Strike Price
- B = Black-Scholes Valuation
- σ = Volatility
- G = Expected Stock Growth
- r = Discount Rate
- L = Expected Lifetime
- λ = Out-of-the-money adjustment

EXAMPLE

Discounted Actual Value	$17.78
MARS Prediction	$15.94
Black-Scholes (Eff. Maturity)	$3.53
GE-FASB123	$1.53