LECTURE 7

APPLICATIONS OF OPTION PRICING THEORY TO EQUITY VALUATION

- Most equity analysts do not associate option pricing theory with equity or asset valuation.
- This Lecture will aim to show that option pricing theory has an important role o play in valuation and that it provides a very different perspective that can be useful in understanding and analyzing troubled firms, natural resource firms, and high-technology firms.

Valuing Equity as an option

- Traditional methods for valuing equity include DCF, Trading and Acquisition Multiples,
- The equity in a firm is a residual claim – that is, euity holders lay claim to all cash flows over after financial claimholders (debt, preferred stock) have been satisfied.
- The payoff to equity investors, on a liquidation basis (bottom of the waterfall) can therefore be written as:

Payoff to equity on liquidation = EV – D if EV > D
and = 0 if EV $\leq$ D

where EV = Enterprise Value and D = Debt

- A Call option with strike price (X) on an asset with a current value of stock (S) has the following payoffs:

Payoff on Exercise =   S – X if S > X
And = 0 if S $\leq$ X

Equity can thus be viewed as a call option on the firm, where exercising the option requires that the firm be liquidated and the face values of the debt (which corresponds to the exercise price) be paid off.

Example

- Asset Value / Enterprise Value of the firm = $100 million
- Standard Deviation in the asset value = 40%
- Face Value of the Debt = $80 million (10 year – zero coupon debt at 10%) – (estimated PV of $80 million at 10% for 10 years = $30.84 not using e compounding)

How much is the equity worth today?
What should the interest rate on debt be?

The use of option pricing approach provides a solution:

- Value of underline asset = S = Value of the firm = $100 million
- Exercise Price = X = Face Value of outstanding Debt = $80 million
- Life of the option = t = Life of zero-coupon debt = 10 years
- Variance in the value of the underlying asset = σ^2 = Variance in EV = $.4^2$ = .16
- Riskless Rate = i = 10 year T-Bonds rate to option life = 10%

d1 = 1.5994 and d2 = .3345
N(d1) = .9451 and N(d2) = .6310

Value of the Call using Black-Scholes:

$(100 \times .9451) - (\$80\ e^{-.10 \times .10} \times .6310) = \$75.94$ million

Value of outstanding debt = $100 - $75.94 = $24.06 million

Increase rate on debt = $(\$80 / \$24.06)^{1/10} - 1 = \mathbf{12.77}$%

Valuing Equity in a Troubled Firm using Option Pricing

- The first implication is that equity will have value, even if the value of the firm falls well below the face value of the outstanding debt
- Such a firm will be viewed as troubled by investors, accountants and analysts, but that does not mean that it's equity is worthless.
- There is a possibility that the underlying value might increase by expiration day.

Example – (using the example above)

- Asset Value / Enterprise Value of the firm = $50 million
- Standard Deviation in the asset value = 40%

- Face Value of the Debt = $80 million (10 year – zero coupon debt at 10%) – (estimated PV of $80 million at 10% for 10 years = $30.84 not using the e compounding)

The $50mm is well below the $80 million outstanding debt (due 10 years from now)

The use of option pricing approach provides a solution:

- Value of underline asset = S = Value of the firm = $50 million
- Exercise Price = X = Face Value of outstanding Debt = $80 million
- Life of the option = t = Life of zero-coupon debt = 10 years
- Variance in the value of the underlying asset = σ^2 = Variance in EV = $.4^2$ =.16
- Riskless Rate = i = 10 year T-Bonds rate to option life = 10%

d1 = 1.0515 and d2 = - .2135
N(d1) = .8534 and N(d2) = .4155

Value of the Call using Black-Scholes:

(50 x .8534) – ($80 e $^{-.10x.10}$ x .4155 = $30.44 million

Value of outstanding debt = $50 - $30.44 = **$19.56 million**

The Equity in this firm has substantial value, because of the option characteristics of equity. This might explain why stock in firms that are in "Chapter 11" and essentially bankrupt still has value.

The Conflict between Bondholders and Stockholders

- Different objectives between Stockholders and Bondholders (Risk)
- This conflict can be illustrated dramatically using the option pricing model.

Example – (using the example above)

- Asset Value / Enterprise Value of the firm = $100 million
- Standard Deviation in the asset value = 40%
- Face Value of the Debt = $80 million (10 year – zero coupon debt at 10%) – (estimated PV of $80 million at 10% for 10 years = $30.84)

- Value of the Equity = E = $74.94 million
- Value of the Debt = D = $24.06 million
- Value of the Firm = EV = $100 million

Now assume that the stockholders have the opportunity to take a project with negative net present value of - $2 million, but assume that this project is very risky project that will push up the standard deviation in firm value to 50%. The equity as a call option can then be valued using he following inputs:

- Value of underline asset = S = Value of the firm = $98 million (100-2)
- Exercise Price = X = Face Value of outstanding Debt = $80 million
- Life of the option = t = Life of zero-coupon debt = 10 years
- Variance in the value of the underlying asset = σ^2 = Variance in EV = $.5^2$ =.25
- Riskless Rate = i = 10 year T-Bonds rate to option life = 10%

Based on Black-Scholes:

- Value of the Equity = E = $77.71million
- Value of the Debt = D = $20.29 million
- Value of the Firm = EV = $98 million

The value of equity rises from $75.94 million to $77.71 million, even though the firm value declines by $2 million. The increase in equity value comes at the expense of bondholders, who see their wealth decline from $24.06 million to $20.19 million.

Valuing Equity as an Option: Wang Labs
File for Bankruptcy 1993

DEBT ASSUMPTIONS		VALUE ASSUMPTIONS (Pre-bankrupcy)	
Debt Outstanding =	529.4	Stock Montly Var. (1987 - 1991) =	0.0262
Weighted Average Duration=	5.1 years	Bonds Monthly Var. (1987 - 1991) =	0.0126
Weighted Average maturity=	8.7 years	Correlation between Stock/Bond	0.27
WACC=	10%	Debt proportion (1987 - 1991) =	86.10%
Tax Rate =	36.0%		

Discount Cash Flow Analysis		1993	1994	1995	1996	1997
Revenue		1,300.0	1,010.0	1,067.0	1,121.0	1,177.0
CoGS		(1,000.0)	(658.0)	(705.0)	(741.0)	(778.0)
Oper. Exp.		(750.0)	(279.0)	(267.0)	(269.0)	(282.0)
EBIT		**(450.0)**	**73.0**	**95.0**	**111.0**	**117.0**
EBIT (t)		**(162.0)**	**26.3**	**34.2**	**40.0**	**42.1**
EBIT (i-t)		**(288.0)**	**46.7**	**60.8**	**71.0**	**74.9**
Less Capex (offset by Depreciation		-	-	-	-	-
Less W/C		-	-	-	-	-
Cash Flow		(288.0)	46.7	60.8	71.0	74.9
Terminal Value assumption	6.8x					794.0
EV (PV) of the firm	**$410.5**	**(288.0)**	**46.7**	**60.8**	**71.0**	**868.9**

Step 1 - Find the annualized in stock and bond prices:

Annualized Variance in Stock Price σ^2 =	0.3144 (annual)	St. Dev.=	0.560714
Annualized Variance in Bond Price σ^2 =	0.1512 (annual)	St. Dev.=	0.388844

Step 2 - Find the annualized variance in firm value

$$(we^2 \times \sigma e^2) + (wb^2 \times \sigma b^2) + (we \times wd \times ped \times \sigma e \times \sigma d)$$

We =	13.90%
Wd =	86.10%

Annualized Varaince in firm value   0.132253

The five-year bond rate (corresponding to the weighted average duration of 5.1 years) is 6.0%

Stet 3 - Find the value of call based upon the following parameters of equity as a call option

Value of the underlying asset = S = Value of the firm =	$410.5
Exercise Price = X = Face Value of outstanding debt =	$529.4
Life of the option = t = Weighted average duration of debt=	5.1 years
Variance in the value of the underlying asset = σ^2 =	0.132253
Riskless Rate = I = T-Bond for option life =	6.00%

d1=	0.473506	N (d1) =	0.682074
d2=	-0.347767	N (d2) =	0.364008

Value of the call =   137.9534

Wang's equity was trading at $85 milion in March 1993

CASE STUDY: Airline Company

NYSE Stock Standard Deviation=	25%	
Debt average % o EV=	90%	
Bond Rating =	B	bonds are not traded
Other B ratednames Stand Dev=	10%	
Correlation Stock/Bond market	0.3	
Dividends =	0	
T-Bond	8.00%	

Enterprise Value	
North America	400
Europe	500
South America	100
	1000

Debt	Amount	% Total	Coupon	Duration	WA Dur
20-yr debt	100	8.33%	11.0%	14.1	1.1750
15-yr debt	100	8.33%	12.0%	10.2	0.8500
10 yr debt	200	16.67%	12.0%	7.5	1.2500
1-yr debt	800	66.67%	12.5%	1.0	0.6667
Total Debt	1200	100.00%			3.9417

Variance of the Firm	% W	σ	W^2	σ^2	W^2xSD^2	We.Wd.σe.σd
Equity % of Cap	10%	25%	0.01	0.0625	0.00063	
Debt % of Cap	90%	10%	0.81	0.01	0.00810	
					0.00873	0.00225
					Variance =	0.01098
					Stand Dev=	0.104761634

Value of Equity using Option Priocing (Black-Scholes)					
		Ln (EV / Debt)	(i + σ^2/2)*t	σ?t	d1 and d2
d1=	0.7435	-0.182321557	0.34	0.21	0.7435
d2=	0.5355				0.5355
N(d1)=	0.7714				
N(d2)=	0.7039				
Value of the Call=	154.63				