CHAPTER 30

VALUING EQUITY IN DISTRESSED FIRMS

In Chapter 22, we examined how discounted cash flow models could be adapted to value firms with negative earnings. In most of our solutions, we estimated the expected cash flows into the future and assumed that an improvement in margins or earnings would result in positive cash flows and firm value. In the special case where the firm has substantial amounts of debt, we argued that there is a very real possibility of defaulting on the debt and going bankrupt. In these cases, discounted cash flow valuation may be an inadequate tool for estimating value. In this chapter, we look at firms with negative earnings, significant assets in place and substantial debt. We argue that the equity investors in this firm, given limited liability, have the option to liquidate the firm and pay off the debt. This call option on the underlying firm can add value to equity, especially when there is significant uncertainty about the value of the assets.

Equity in Highly Levered distressed firms

In most publicly traded firms, equity has two features. The first is that the equity investors run the firm and can choose to liquidate its assets and pay off other claim holders at any time. The second is that the liability of equity investors in some private firms and almost all publicly traded firms is restricted to their equity investments in these firms. This combination of the option to liquidate and limited liability allows equity to have the features of a call option. In firms with substantial liabilities and negative earnings, the option value of equity may be in excess of the discounted cash flow value.

The Payoff on Equity as an Option

The equity in a firm is a residual claim, that is, equity holders lay claim to all cash flows left after other financial claimholders (debt, preferred stock, etc.) have been satisfied. If a firm is liquidated, the same principle applies; equity investors receive the cash that is left in the firm after all outstanding debt and other financial claims have been paid off. With limited liability, if the value of the firm is less than the value of the outstanding debt, equity investors cannot lose more than their investment in the firm. The payoff to equity investors on liquidation can therefore be written as:

Payoff to equity on liquidation	= V - D	if V > D
	= 0	if V ≤ D

where

V = Liquidation Value of the firm

D = Face Value of the outstanding debt and other external claims

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 value of the debt (which corresponds to the exercise price) be paid off. The firm is the underlying asset and the option expires when the debt comes due. The payoffs are shown in Figure 30.1.

Figure 30.1: Payoff on Equity as Option on a Firm

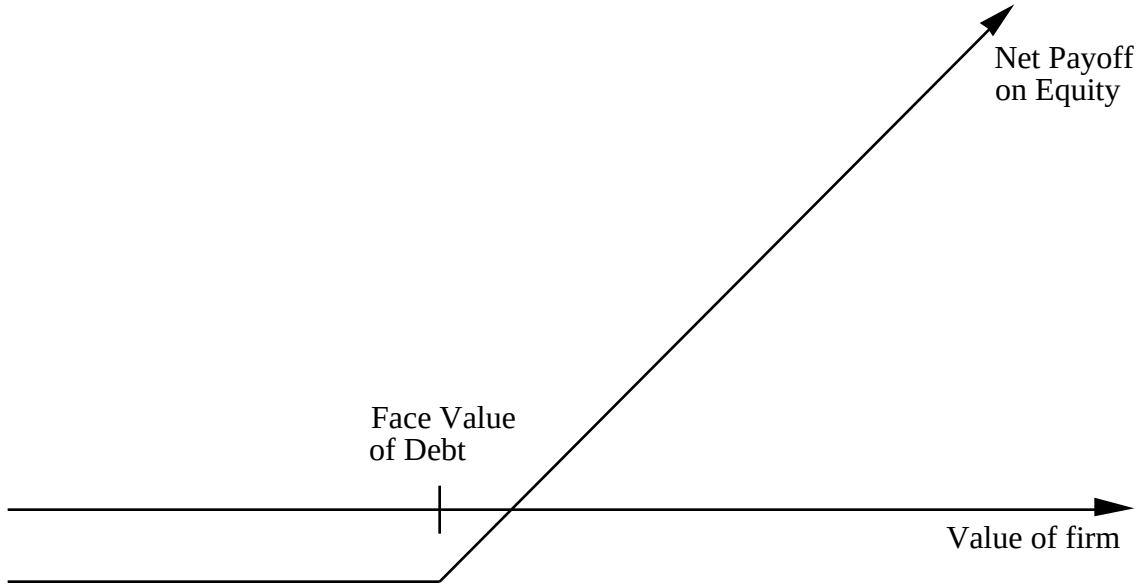


Illustration 30.1: Valuing Equity as an Option

Assume that you are valuing the equity in a firm whose assets are currently valued at $100 million; the standard deviation in this asset value is 40%. The face value of debt is $80 million (it is zero coupon debt with 10 years left to maturity). The 10-year treasury bond rate is 10%. We can value equity as a call option on the firm, using the following inputs for the option pricing model.

Value of the underlying asset = S = Value of the firm = $ 100 million

Exercise price = K = 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 firm value = 0.16

Riskless rate = r = Treasury bond rate corresponding to option life = 10%

Based upon these inputs, the Black-Scholes model provides the following value for the call.

d_1 = 1.5994 $N(d_1)$ = 0.9451

d_2 = 0.3345 $N(d_2)$ = 0.6310

Value of the call $= 100(0.9451) - 80e^{(-0.10)(10)}(0.6310) = \$75.94$ million

Since the call value represents the value of equity and the firm value is $100 million, the estimated value of the outstanding debt can be calculated.

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

Since the debt is a 10-year zero coupon bond, the market interest rate on the bond can be calculated.

Interest rate on debt $= \left(\frac{\$80}{\$24.06}\right)^{\frac{1}{10}} - 1 = 12.77\%$

Thus, the default spread on this bond should be 2.77%.

The Importance of Limited Liability

The argument that equity is a call option holds only if equity has limited liability – i.e., the most that an equity investor can lose is what he or she has invested in a firm. This is clearly the case in publicly traded companies. In private companies, however, the owners often have unlimited liability. If these firms get into financial trouble and are unable to make their debt payments, the owner's personal assets can be put at risk. You should not value equity as a call option in these cases.

Implications of viewing Equity as an Option

When the equity in a firm takes on the characteristics of a call option, you have to change the way you think about its value and what determines its value. In this section, we will consider a number of potential implications for equity investors and bondholders in the firm.

When will equity be worthless?

In discounted cash flow valuation, we argue that equity is worthless if what you own (the value of the firm) is less than what you owe. The first implication of viewing equity as a call option is that equity will have value, even if the value of the firm falls well below the face value of the outstanding debt. While the firm will be viewed as troubled by investors, accountants and analysts, its equity is not worthless. In fact, just as deep out-of-the-money traded call options command value because of the possibility that the value of the underlying asset may increase above the strike price in the remaining lifetime of the option, equity commands value because of the time premium on the option (the time until the bonds mature and come due) and the possibility that the value of the assets may increase above the face value of the bonds before they come due.

Illustration 30.2: Firm Value and Equity Value

Revisiting the preceding example, assume that the value of the firm drops to $50 million, below the face value of the outstanding debt ($80 million). Assume that all the other inputs remain unchanged. The parameters of equity as a call option are as follows:

Value of the underlying asset = S = Value of the firm = $ 50 million

Exercise price = K = 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 firm value = 0.16

Riskless rate = r = Treasury bond rate corresponding to option life = 10%

Based upon these inputs, the Black-Scholes model provides the following value for the call.

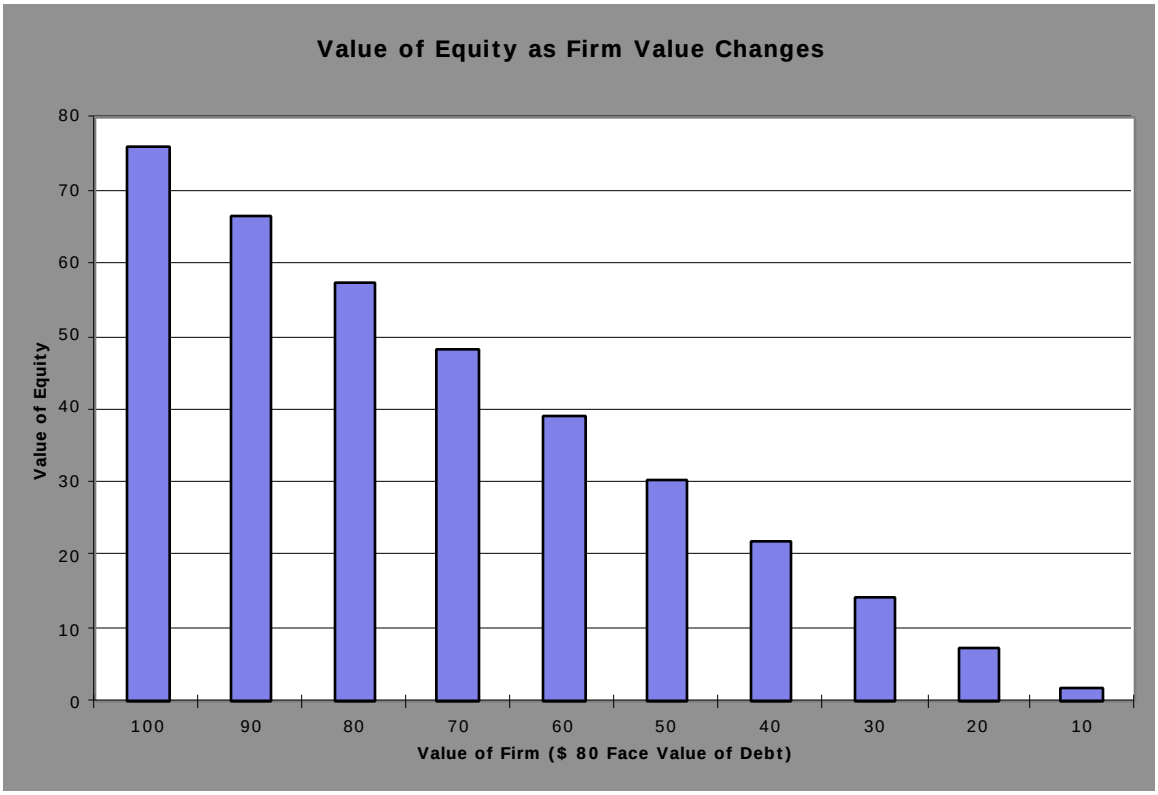
$d_1 = 1.0515$ $N(d_1) = 0.8534$

$d_2 = -0.2135$ $N(d_2) = 0.4155$

Value of the call (equity) = $50 (0.8534) - 80 \exp^{(-0.10)(10)} (0.4155) = \$30.44$ million

Value of the bond= $50 - $30.44 = $19.56 million

As you can see, the equity in this firm retains value, because of the option characteristics of equity. In fact, equity continues to have value in this example even if the firm value drops to $10 million or below, as shown in Figure 30.2.



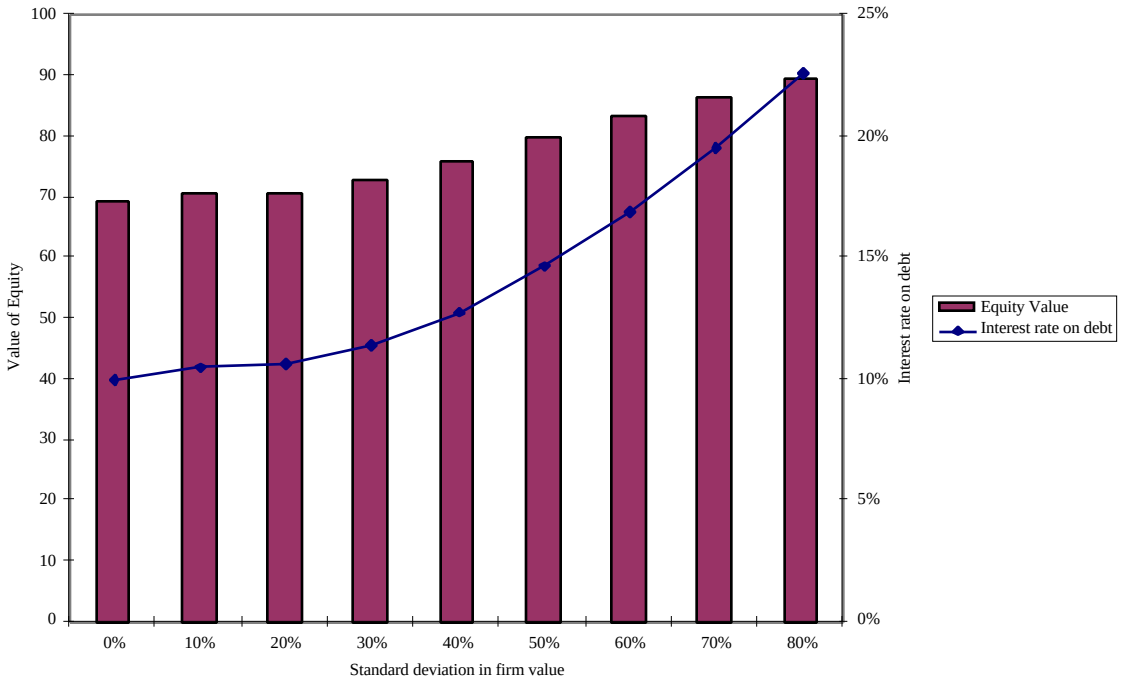
Increasing Risk can increase Equity Value

In traditional discounted cash flow valuation, higher risk almost always translates into lower value for equity investors. When equity takes on the characteristics of a call option, you should not expect this relationship to continue to hold. Risk can become your ally, when you are an equity investor in a troubled firm. In essence, you have little to lose and much to gain from swings in firm value.

Illustration 30.3: Equity Value and Volatility

Let us revisit the valuation in Illustration 30.1. The value of the equity is a function of the variance in firm value, which we assumed to be 40%. If we change this variance, holding all else constant, the value of the equity will change as evidenced in Figure 30.3.

Figure 30.3: Equity Value and Standard Deviation in Firm Value



Note that the value of equity increases, if we hold firm value constant, as the standard deviation increases. The interest rate on debt also increases as the standard deviation increases.

Probability of Default and Default Spreads

One of the more interesting pieces of output from the option pricing model is the risk-neutral probability of default that you can obtain for the firm. In the Black-Scholes model, you can estimate this value from N(d2), which is the risk-neutral probability that S>K, which in this model is the probability that the value of the firm's asset will exceed the face value of the debt.

$$\text{Risk-neutral probability of default} = 1 - N(d2)$$

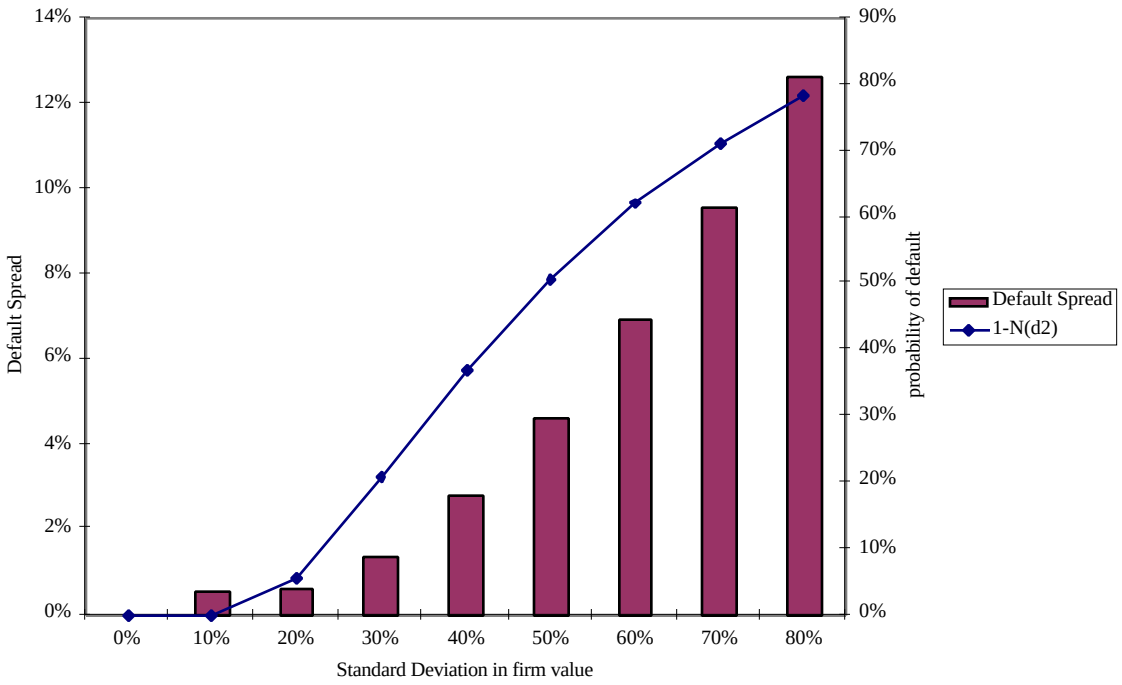
In addition, the interest rate from the debt allows us to estimate the appropriate default spread to charge on bonds.

You can see the potential in applying this model to bank loan portfolios to extract both the probability of default and to measure whether you are charging an interest rate that is high enough on the debt. In fact, there are commercial services that use fairly sophisticated option pricing models to estimate both values for firms.

Illustration 30.4: Probabilities of default and Default Spreads

We return to Illustration 30.1 and estimate the probability of default as N(d2) and the default spread, measured as the difference between the interest rate on a firm's debt and the riskfree rate, as a function of the variance. These values are graphed in Figure 30.4.

Figure 30.4: Risk Neutral Probability of default and Default spreads



Note that the probability of default climbs very quickly as the standard deviation in firm value increases and the default spread follows it along.

Estimating the Value of Equity as an Option

The examples we have used thus far to illustrate the application of option pricing to value equity have included some simplifying assumptions. Among them are the following.

1. There are only two claimholders in the firm - debt and equity.
2. There is only one issue of debt outstanding and it can be retired at face value.
3. The debt has a zero coupon and no special features (convertibility, put clauses, etc.)
4. The value of the firm and the variance in that value can be estimated.

Each of these assumptions is made for a reason. First, by restricting the claimholders to just debt and equity, we make the problem more tractable; introducing other claimholders such as preferred stock makes it more difficult to arrive at a result, albeit not impossible. Second, by assuming only one zero-coupon debt issue that can be retired at face value any time prior to maturity, we align the features of the debt more closely to the features of the strike price on a standard option. Third, if the debt is coupon debt, or more than one debt issue is outstanding, the equity investors can be forced to exercise (liquidate the firm) at these earlier coupon dates if they do not have the cash flows to meet their coupon obligations.

Finally, knowing the value of the firm and the variance in that value makes the option pricing possible, but it also raises an interesting question about the usefulness of option pricing in equity valuation. If the bonds of the firm are publicly traded, the market value of the debt can be subtracted from the value of the firm to obtain the value of equity much more directly. The option pricing approach does have its advantages, however. Specifically, when the debt of a firm is not publicly traded, option pricing theory can provide an estimate of value for the equity in the firm. Even when the debt is publicly traded, the bonds may not be correctly valued and the option pricing framework can be useful in evaluating the values of debt and equity. Finally, relating the values of debt and equity to the variance in firm value provides some insight into the redistributive effects of actions taken by the firm.

Inputs for Valuing Equity as an Option

Since most firms do not fall into the neat framework developed above (such as having only one zero-coupon bond outstanding), we have to make some compromises to use this model in valuation.

Value of the Firm

We can obtain the value of the firm in one of four ways. In the first, we cumulate the market values of outstanding debt and equity, assuming that all debt and equity are traded, to obtain firm value. The option pricing model then reallocates the firm value between debt and equity. This approach, while simple, is internally inconsistent. We start

with one set of market values for debt and equity and, using the option pricing model, end up with entirely different values for each.

In the second, we estimate the market values of the assets of the firm by discounting expected cash flows at the cost of capital. The one consideration that we need to keep in mind is that the value of the firm in an option pricing model should be the value obtained on liquidation. This may be less than the total firm value, which includes expected future investments and it may also be reduced to reflect the cost of liquidation. If we estimate the firm value using a discounted cash flow model, then this would suggest that only existing investments[1] should be considered while estimating firm value. The biggest problem with this approach is that financial distress can affect operating income and thus the value that you obtain by using current operating income may be too low.

In the third approach, we estimate a multiple of revenues by looking at healthy firms in the same business and apply this multiple to the revenues of the firm you are valuing. Implicitly, we are assuming that a potential buyer, in the event of liquidation, will pay this value.

We can use the third approach for firms that have separable assets that are individually traded. For example, we can value a troubled real estate firm that owns five properties by valuing each property separately and then aggregating the values.

Variance in Firm value

We can obtain the variance in firm value directly if both stocks and bonds in the firm are traded. Defining σ_e^2 as the variance in the stock price and σ_d^2 as the variance in the bond price, w_e as the market-value weight of equity and w_d as the market-value weight of debt, we can write the variance in firm value as:[2]

$$\sigma^2_{firm} = w_e^2\sigma_e^2 + w_d^2\sigma_d^2 + 2w_e w_d \rho_{ed}\sigma_e\sigma_d$$

where ρ_{ed} is the correlation between the stock and the bond prices. When the bonds of the firm are not traded, we can use the variance of similarly rated bonds as the estimate of

[1] Technically, this can be done by putting the firm into stable growth and valuing it as a stable growth firm, where reinvestments are used to either preserve or augment existing assets.
[2] This is an extension of the variance formula for a two-asset portfolio.

σ_d^2 and the correlation between similarly rated bonds and the firm's stock as the estimate of ρ_{ed}.

When companies get into financial trouble, this approach can yield misleading results as both its stock prices and its bond prices become more volatile. An alternative that often yields more reliable estimates is to use the average variance in firm value for other firms in the sector. Thus, the value of equity in a deeply troubled steel company can be estimated using the average variance in firm value of all traded steel companies.


optvar.xls: There is a dataset on the web that summarizes standard deviations in equity and firm value, by industry, for firms in the United States.

Maturity of the Debt

Most firms have more than one debt issue on their books and much of the debt comes with coupons. Since the option pricing model allows for only one input for the time to expiration, we have to convert these multiple bonds issues and coupon payments into one equivalent zero-coupon bond.

- One solution, which takes into account both the coupon payments and the maturity of the bonds, is to estimate the duration of each debt issue and calculate a face-value-weighted average of the durations of the different issues. This value-weighted duration is then used as a measure of the time to expiration of the option.
- An approximation is to use the face-value weighted maturity of the debt converted to the maturity of the zero-coupon bond in the option pricing model.

Face Value of Debt

When a distressed firm has multiple debt issues outstanding, you have three choices when it comes to what you use as the face value of debt:

- You could add up the principal due on all of the debt of the firm and consider it to be the face value of the hypothetical zero coupon bond that you assume that the firm has issued. The limitation of this approach is that it will understate what the

firm will truly have to pay out over the life of the debt, since there will be coupon payments and interest payments during the period.

- At the other extreme, you could add the expected interest and coupon payments that will come due on the debt to the principal payments to come up with a cumulated face value of debt. Since the interest payments occur in the near years and the principal payments are due only when the debt comes due, you are mixing cash flows up at different points in time when you do this. This is, however, the simplest approach of dealing with intermediate interest payments coming due.
- You can consider only the principal due on the debt as the face value of the debt and the interest payments each year, specified as a percent of firm value, can take the place of the dividend yield in the option pricing model. In effect, each year that the firm remains in existence, you would expect to see the value of the firm decline by the expected payments on the debt.

Illustration 30.5: Valuing Equity as an option – Eurotunnel in 1997

Eurotunnel was the firm that was created to build and ultimately profit from the tunnel under the English Channel, linking England and France. While the tunnel was readied for operations in the early 1990s, it was never a commercial success and reported significant losses each year after opening. In early 1998, Eurotunnel had a book value of equity of -£117 million, and in 1997, the firm had reported earnings before interest and taxes of -£3.45 million and net income of -£611 million on revenues of £456 million. By any measure, it was a firm in financial trouble.

Much of the financing for the tunnel had come from debt and, at the end of 1997, Eurotunnel had debt obligations in excess of £5,000 million, raised from a variety of bond issues and bank debt. Adding the expected interest payments and coupon payments on the debt brings the total obligations of the firm up to £8,865 million. The following table summarizes the outstanding debt at the firm, with our estimates of the expected duration for each class of debt.

Table 30.1: Debt Breakdown for Eurotunnel

Debt Type	*Face Value (including cumulated coupons)*	*Duration*
Short term	£ 935	0.50

10 year	£ 2435	6.7
20 year	£ 3555	12.6
Longer	£ 1940	18.2
Total	£8,865 mil	10.93 years

The firm's only significant asset is its ownership of the tunnel and we estimated the value of this asset from its expected cash flows and the appropriate cost of capital. The assumptions we made were as follows.

1. Revenues will grow 10% a year for the next 5 years and 3% a year in perpetuity after that.
2. The cost of goods sold which was 72% of revenues in 1997 will drop to 60% of revenues by 2002 in linear increments and stay at that level.
3. Capital spending and depreciation will grow 3% a year for the next 5 years. Note that the net capital expenditure is negative for each of these years – we are assuming that the firm will be able to not make significant reinvestments for the next 5 years. Beyond year 5, capital expenditures will offset depreciation.
4. There are no working capital requirements.
5. The debt ratio, which was 95.35% at the end of 1997, will drop to 70% by 2002. The cost of debt is 10% for the next 5 years and 8% after that.
6. The beta for the stock will be 2.00 for the next five years, and drop to 0.8 thereafter (as the leverage decreases).

The long-term bond rate at the time of the valuation was 6% and the tax rate was 35%. Based on these assumptions, we estimated the cash flows in Table 30.2.

Table 30.2: Estimated FCFF: Eurotunnel

	1	*2*	*3*	*4*	*5*	*Terminal Year*
Revenues	$501.60	$551.76	$606.94	$667.63	$734.39	$756.42
- COGS	$361.15	$380.71	$400.58	$420.61	$440.64	$453.85
- Depreciation	$141.11	$145.34	$149.70	$154.19	$158.82	$163.59
EBIT	($0.66)	$25.70	$56.65	$92.83	$134.94	$138.98
- EBIT*t	$0.00	$9.00	$19.83	$32.49	$47.23	$48.64
EBIT (1-t)	($0.66)	$16.71	$36.83	$60.34	$87.71	$90.34
+ Depreciation	$141.11	$145.34	$149.70	$154.19	$158.82	$163.59
- Capital Spending	$46.35	$47.74	$49.17	$50.65	$52.17	$163.59

- Chg. Working Capital	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Free CF to Firm	$94.10	$114.31	$137.36	$163.89	$194.36	$90.34
Terminal Value					$2,402.66	
Present Value	$87.95	$99.86	$112.16	$125.08	$1,852.67	
Value of firm =	$2,277.73					

The value of the assets of the firm is £2,278 million.

The final input we estimated was the standard deviation in firm value. Since there are no directly comparable firms, we estimated the standard deviations in Eurotunnel stock and debt using the data over the previous years.

Standard deviation in Eurotunnel stock price (ln) = 41%

Standard deviation in Eurotunnel bond price (ln) = 17%

We also estimated a correlation of 0.50 between Eurotunnel stock and bond prices and the average market debt to capital ratio during the two-year period was 85%. Combining these inputs, we estimated the standard deviation in firm value to be:

$$\sigma^2_{firm} = (0.15)^2(0.41)^2 + (0.85)^2(0.17)^2 + 2(0.15)(0.85)(0.5)(0.41)(0.17) = 0.0335$$

In summary, the inputs to the option pricing model were as follows.

Value of the underlying asset = S = Value of the firm = £2,278 million

Exercise price = K = Face Value of outstanding debt = £8,865 mil

Life of the option = t = Weighted average duration of debt = 10.93 years

Variance in the value of the underlying asset = σ^2 = Variance in firm value = 0.0335

Riskless rate = r = Treasury bond rate corresponding to option life = 6%

Based upon these inputs, we estimate the following value for the call:

$d_1 = -0.8582$ $N(d_1) = 0.1955$

$d_2 = -1.4637$ $N(d_2) = 0.0717$

$$\text{Value of the call} = 2{,}278(0.1955) - 8{,}865e^{(-0.06)(10.93)}(0.0717) = \$116 \text{ million}$$

Eurotunnel's equity was trading at £150 million in 1997.

The option pricing framework, in addition to yielding a value for Eurotunnel equity, yields some valuable insight into the drivers of value for this equity. While it is certainly important that the firm try to bring costs under control and increase operating margins, the two most critical variables determining equity value are the duration of the

debt and the variance in firm value. Any action that increases (decreases) the debt duration will have a positive (negative) effect on equity value. For instance, when the French government put pressure on the bankers who had lent money to Eurotunnel to ease restrictions and allow the firm more time to repay its debt, equity investors benefited as their options became more long term. Similarly, an action that increases the volatility of expected firm value will increase the value of the option.


equity.xls: This spreadsheet allows you to estimate the value the equity in a troubled firm as an option.

Vulture Investing and Option Pricing

Vulture investing refers to an investment strategy of buying the securities of firms that are in severe financial distress. In a sense, you are investing in deep out of the money options and hoping that some of these options pay off handsomely. Using the option pricing framework allows us to draw some conclusions about when and how this strategy can pay off.

- As with any portfolio of deep out-of-the-money options, you should expect a considerable proportion of the portfolio to end up worthless. The relatively few investments that do pay off, however, will earn huge returns and you could still end up with a portfolio with impressive returns.
- You should direct your equity investments to equity in deeply troubled firms in volatile sectors. Risk is your ally when you invest in options; and the equity in these firms should be worth more than equity in deeply troubled stable firms.
- If you are buying equity in deeply troubled firms, you should direct your investments towards troubled firms with longer term debt rather than shorter tem debt. As the life of the option increases, you will see the value of the option also increase.
- If you are investing in the debt issued by financially troubled firms, you cannot be a passive bondholder. You have to take an active role in the management and obtain an equity stake in the companies you invest in, perhaps by making the debt convertible.

Consequences for decision making

Option pricing theory can be applied to illustrate the conflict between stockholders and bondholders when it comes to investment analysis and conglomerate mergers. In this section, we will argue that decisions that make stockholders better off are not necessarily value maximizing for the firm and can hurt bondholders.

The Conflict between Bondholders and Stockholders

Stockholder and bondholders have different objective functions, and this can lead to agency problems, whereby stockholders expropriate wealth from bondholders. The conflict can manifest itself in a number of ways. For instance, stockholders have an incentive to invest in riskier projects than bondholders and to pay more out in dividends than bondholders would like them to. The conflict between bondholders and stockholders can be illustrated dramatically using the option pricing methodology developed in the previous section.

Investing in Risky Projects

Since equity is a call option on the value of the firm, other things remaining equal, an increase in the variance in the firm value will lead to an increase in the value of equity. It is therefore conceivable that stockholders can invest in risky projects with negative net present values, which, while making them better off, may make the bonds and the firm less valuable. To illustrate, consider the firm in Illustration 30.1 with a value of assets of $100 million, a face value of zero-coupon ten-year debt of $80 million and a standard deviation in the value of the firm of 40%. The equity and debt in this firm were valued as follows:

Value of Equity = $75.94 million

Value of Debt = $24.06 million

Value of Firm == $100 million

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

Value of the underlying asset = S = Value of the firm = $ 100 million - $2 million = $ 98 million (The value of the firm is lowered because of the negative net present value project.)

Exercise price = K = 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 firm value = 0.25

Riskless rate = r = Treasury bond rate corresponding to option life = 10%

Based upon these inputs, the Black-Scholes model provides the following value for the equity and debt in this firm.

Value of Equity = $77.71

Value of Debt = $20.29

Value of Firm = $98.00

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 find their wealth decline from $24.06 million to $20.29 million.

Conglomerate Mergers

Bondholders and stockholders may also be affected differently by conglomerate mergers, where the variance in earnings and cash flows of the combined firm can be expected to decline because the merging firms have earning streams that are not perfectly correlated. In these mergers, the value of the combined equity in the firm will decrease after the merger because of the decline in variance; consequently, bondholders will gain. Stockholders can reclaim some or all of this lost wealth by utilizing their higher debt capacity and issuing new debt. To illustrate, suppose you are provided with the following information on two firms, Lube and Auto (auto service) and Gianni Cosmetics (a cosmetics manufacturer) that hope to merge.

	Lube & Auto	*Gianni Cosmetics*	
Value of the firm	$100 million	$ 150 million	
Face Value of Debt	$ 80 million	$ 50 million	(Zero-coupon debt)
Maturity of debt	10 years	10 years	
Std. Dev. in firm value	40 %	50 %	

Correlation between firm cash flows 0.4

The ten-year bond rate is 10%.

We calculate the variance in the value of the firm after the acquisition as follows:

$$\text{Variance in combined firm value} = w_e^2\sigma_e^2 + w_d^2\sigma_d^2 + 2w_e w_d \rho_{ed}\sigma_e\sigma_d$$
$$= (0.4)^2(0.4)^2 + (0.6)^2(0.5)^2 + 2(0.4)(0.6)(0.4)(0.4)(0.5)$$
$$= 0.154$$

We estimate the values of equity and debt in the individual firms and the combined firm using the option pricing model.

	Lube & Auto	Gianni	Combined firm
Value of equity in the firm	\$75.94	\$134.48	\$ 207.58
Value of debt in the firm	\$24.06	\$ 15.52	\$ 42.42
Value of the firm	\$100.00	\$150.00	\$ 250.00

The combined value of the equity prior to the merger is \$ 210.42 million; it declines to \$207.58 million after that. The wealth of the bondholders increases by an equal amount. There is a transfer of wealth from stockholders to bondholders, as a consequence of the merger. Thus, conglomerate mergers that are not followed by increases in leverage are likely to result in a wealth transfer from stockholders to bondholders.

Is equity not a call option in every firm?

Looking at the framework that we have employed in this chapter, you are probably wondering why equity in every firm cannot be viewed as a call option and why therefore we should not add a premium to discounted cash flow values for all firms. It is true that equity is a call option in every firm, but in most firms, the value of the firm as a going concern will be greater than the value you obtain from a liquidation option. Consider, for instance, a high growth firm with very little in assets in place and a high proportion of value from growth potential. If this firm liquidates, it will get the value of its asset in place – this will become the value of the underlying asset in the option pricing model and determine the value of equity as a call option on the firm. This value will be much lower than the value you would obtain if you valued the firm as a going concern and considered the cash flows from expected growth.

Value of equity = Maximum (Equity value as a going concern from a discounted cashflow valuation, Equity value as a call option on liquidation)

For some mature firms that derive most of their value coming from assets in place and substantial debt, the call option can be the higher value. For other firms, though, the going concern will be greater.

Summary

The value of equity in deeply troubled firms - firms with negative earnings and high leverage - can be viewed as a call option. The option rests in the hands of equity investors, who can choose to liquidate the firm and claim the difference between firm value and debt outstanding. With limited liability, they do not have to make up the difference if firm value falls below the value of the outstanding debt. The equity will retain value even when the value of the assets of the firm is lower than the debt outstanding, because of the time premium on the option.

Problems

1. Designate the following statements as true or false.

a. Equity can be viewed as an option because equity investors have limited liability (limited to their equity investment in the firm).

b. Equity investors will sometimes take bad projects (with negative net present value) because they can add to the value of the firm.

c. Investing in a good project (with positive NPV) -- which is less risky than the average risk of the firm -- can negatively impact equity investors.

d. The value of equity in a firm is an increasing function of the duration of the debt in the firm (i.e., equity will be more valuable in a firm with longer term debt than an otherwise similar firm with short term debt).

e. In a merger in which two risky firms merge and do not borrow more money, equity can become less valuable because existing debt will become less risky.

2. XYZ Corporation has $500 million in zero-coupon debt outstanding, due in five years. The firm had earnings before interest and taxes of $40 million in the most recent year (the tax rate is 40%). These earnings are expected to grow 5% a year in perpetuity and the firm paid no dividends. The firm had a cost of equity of 12% and a cost of capital of 10%. The annualized standard deviation in firm values of comparable firms is 12.5%. The five-year bond rate is 5%.

a. Estimate the value of the firm.

b. Estimate the value of equity, using an option pricing model.

c. Estimate the market value of debt and the appropriate interest rate on the debt.

3. McCaw Cellular Communications reported earnings before interest and taxes of $850 million in 1993 and had a depreciation allowance of $400 million in that year (which was offset by capital spending of an equivalent amount). The earnings before interest and taxes are expected to grow 20% a year for the next five years and 5% a year after that. The cost of capital is 10%. The firm has $10 billion in debt outstanding with the following characteristics.

Duration	*Debt*
1 year	$2 billion

2 years	$4 billion
5 years	$4 billion

The annualized standard deviation in the firm's stock price is 35%, while the annualized standard deviation in the traded bonds is 15%. The correlation between stock and bond prices has been 0.5. The firm has a debt/equity ratio of 50% and the after-tax cost of debt is 6%. (The beta of the stock is 1.50; the 30-year treasury bond rate is 7%.) The three-year bond rate is 5%.

a. Estimate the value of the firm.

b. Estimate the value of the equity.

c. The stock was trading at $60 and there were 210 million shares outstanding in January 1994. Estimate the implied standard deviation in firm value.

d. Estimate the market value of the debt.

4. You have been asked to analyze the value of equity in a company that has the following features.

- The earnings before interest and taxes is $25 million and the corporate tax rate is 40%. There is no net capital expenditures or working capital requirements and the earnings are expected to grow 5% a year in perpetuity. The cost of capital of comparable firms is 10%.
- The firm has two types of debt outstanding - 2-year zero-coupon bonds with a face value of $250 million and bank debt with ten years to maturity with a face value of $250 million (The duration of this debt is 4 years.).
- The firm is in two businesses - food processing and auto repair. The average standard deviation in firm value for firms in food processing is 25%, whereas the standard deviation for firms in auto repair is 40%. The correlation between the businesses is 0.5.
- The riskless rate is 7%.

Use the option pricing model to value equity as an option.

5. You are valuing the equity in a firm with $800 million (face value) in debt with an average duration of 6 years and assets with an estimated value of $400 million. The

standard deviation in asset value is 30%. With these inputs (and a riskless rate of 6%) we obtain the following values (approximately) for d1 and d2.

d1 = - 0.15 d2 = - 0.90

Estimate the default spread (over and above the riskfree rate) that you would charge for the debt in this firm.