Chapter 15
Capital Structure Decisions

Topics in Chapter
- Overview and preview of capital structure effects
- Business versus financial risk
- The impact of debt on returns
- Capital structure theory, evidence, and implications for managers
- Example: Choosing the optimal structure

Determinants of Intrinsic Value:
The Capital Structure Choice

\[
\text{Value} = \frac{\text{FCF}_1}{(1 + \text{WACC})} + \frac{\text{FCF}_2}{(1 + \text{WACC})^2} + \ldots + \frac{\text{FCF}_n}{(1 + \text{WACC})^n}
\]

- Market interest rates
- Market risk aversion
- Required investments in operating capital
- Free cash flow (FCF)
- Net operating profit after taxes
- Required investments in operating capital

- Cost of debt
- Cost of equity
- Firm’s debt/equity mix
- Firm’s business risk
- Weighted average cost of capital (WACC)
Basic Definitions

- $V =$ value of firm
- $FCF =$ free cash flow
- $WACC =$ weighted average cost of capital
- $r_s$ and $r_d$ are costs of stock and debt
- $w_s$ and $w_d$ are percentages of the firm that are financed with stock and debt.

How can capital structure affect value?

$$ V = \sum_{t=1}^{\infty} \frac{FCF_t}{(1 + WACC)^t} $$

$WACC = w_d (1-T) r_d + w_s r_s$

A Preview of Capital Structure Effects

- The impact of capital structure on value depends upon the effect of debt on:
  - $WACC$
  - $FCF$
Business Risk: Uncertainty in EBIT, NOPAT, and ROIC

- Uncertainty about demand (unit sales).
- Uncertainty about output prices.
- Uncertainty about input costs.
- Product and other types of liability.
- Degree of operating leverage (DOL).

What is operating leverage, and how does it affect a firm’s business risk?

- Operating leverage is the change in EBIT caused by a change in quantity sold.
- The higher the proportion of fixed costs relative to variable costs, the greater the operating leverage.

Higher operating leverage leads to more business risk: small sales decline causes a larger EBIT decline.
Operating Breakeven

- Q is quantity sold, F is fixed cost, V is variable cost, TC is total cost, and P is price per unit.
- Operating break even = $Q_{BE}$
- $Q_{BE} = \frac{F}{(P - V)}$
- Example: F=$200, P=$15, and V=$10:
  - $Q_{BE} = \frac{200}{(15 - 10)} = 40$.  

Business Risk versus Financial Risk

- Business risk:
  - Uncertainty in future EBIT, NOPAT, and ROIC.
  - Depends on business factors such as competition, operating leverage, etc.
- Financial risk:
  - Additional business risk concentrated on common stockholders when financial leverage is used.
  - Depends on the amount of debt and preferred stock financing.

Consider Two Hypothetical Firms Identical Except for Debt

<table>
<thead>
<tr>
<th></th>
<th>Firm U</th>
<th>Firm L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>$20,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>Debt</td>
<td>$0</td>
<td>$10,000 (12% rate)</td>
</tr>
<tr>
<td>Equity</td>
<td>$20,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Tax rate</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>EBIT</td>
<td>$3,000</td>
<td>$3,000</td>
</tr>
<tr>
<td>NOPAT</td>
<td>$1,800</td>
<td>$1,800</td>
</tr>
<tr>
<td>ROIC</td>
<td>9%</td>
<td>9%</td>
</tr>
</tbody>
</table>
### Impact of Leverage on Returns

<table>
<thead>
<tr>
<th></th>
<th>Firm U</th>
<th>Firm L</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBIT</td>
<td>$3,000</td>
<td>$3,000</td>
</tr>
<tr>
<td>Interest</td>
<td>0</td>
<td>1,200</td>
</tr>
<tr>
<td>EBT</td>
<td>$3,000</td>
<td>$1,800</td>
</tr>
<tr>
<td>Taxes (40%)</td>
<td>1,200</td>
<td>720</td>
</tr>
<tr>
<td>NI</td>
<td>$1,800</td>
<td>$1,080</td>
</tr>
<tr>
<td>ROIC</td>
<td>9.0%</td>
<td>9.0%</td>
</tr>
<tr>
<td>ROE (NI/Equity)</td>
<td>9.0%</td>
<td>10.8%</td>
</tr>
</tbody>
</table>

### Why does leveraging increase return?

- More cash goes to investors of Firm L.
  - Total dollars paid to investors:
    - U: NI = $1,800.
    - L: NI + Int = $1,080 + $1,200 = $2,280.
  - Taxes paid:
    - U: $1,200
    - L: $720.
- In Firm L, fewer dollars are tied up in equity.

### Impact of Leverage on Returns if EBIT Falls

<table>
<thead>
<tr>
<th></th>
<th>Firm U</th>
<th>Firm L</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBIT</td>
<td>$2,000</td>
<td>$2,000</td>
</tr>
<tr>
<td>Interest</td>
<td>0</td>
<td>1,200</td>
</tr>
<tr>
<td>EBT</td>
<td>$2,000</td>
<td>$800</td>
</tr>
<tr>
<td>Taxes (40%)</td>
<td>800</td>
<td>320</td>
</tr>
<tr>
<td>NI</td>
<td>$1,200</td>
<td>$480</td>
</tr>
<tr>
<td>ROIC</td>
<td>6.0%</td>
<td>6.0%</td>
</tr>
<tr>
<td>ROE</td>
<td>6.0%</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

Leverage magnifies risk and return!
Capital Structure Theory

- MM theory
  - Zero taxes
  - Corporate taxes
  - Corporate and personal taxes
- Trade-off theory
- Signaling theory
- Pecking order
- Debt financing as a managerial constraint
- Windows of opportunity

MM Theory: Zero Taxes

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<td>$3,000</td>
</tr>
<tr>
<td>Interest</td>
<td>0</td>
<td>1,200</td>
</tr>
<tr>
<td>NI</td>
<td>$3,000</td>
<td>$1,800</td>
</tr>
<tr>
<td>CF to shareholder</td>
<td>$3,000</td>
<td>$1,800</td>
</tr>
<tr>
<td>CF to debtholder</td>
<td>0</td>
<td>$1,200</td>
</tr>
<tr>
<td>Total CF</td>
<td>$3,000</td>
<td>$3,000</td>
</tr>
</tbody>
</table>

Notice that the total CF are identical for both firms.

MM Results: Zero Taxes: $V_L = V_U$

- MM assume: (1) no transactions costs; (2) no restrictions or costs to short sales; and (3) individuals can borrow at the same rate as corporations.
- MM prove that if the total CF to investors of Firm U and Firm L are equal, then arbitrage is possible unless the total values of Firm U and Firm L are equal:
  - $V_L = V_U$
- Because FCF and values of firms L and U are equal, their WACCs are equal.
- Therefore, capital structure is irrelevant.
Corporate tax laws allow interest to be deducted, which reduces taxes paid by levered firms.

Therefore, more CF goes to investors and less to taxes when leverage is used.

In other words, the debt "shields" some of the firm’s CF from taxes.

**MM Result: Corporate Taxes:**

\[ V_L = V_U + TD \]

MM show that the total CF to Firm L’s investors is equal to the total CF to Firm U’s investor plus an additional amount due to interest deductibility:

- \( CF_L = CF_U + r_d DT \).
- What is value of these cash flows?
  - Value of \( CF_U = V_U \)
  - MM show that the value of \( r_d DT = TD \)
  - Therefore, \( V_L = V_U + TD \).
- If \( T=40\% \), then every dollar of debt adds 40 cents of extra value to firm.
Miller’s Theory: Corporate and Personal Taxes

- Personal taxes lessen the advantage of corporate debt:
  - Corporate taxes favor debt financing since corporations can deduct interest expenses.
  - Personal taxes favor equity financing, since no gain is reported until stock is sold, and long-term gains are taxed at a lower rate.

Miller’s Model with Corporate and Personal Taxes

\[ V_L = V_U + \left[ 1 - \frac{(1 - T_d)(1 - T_s)}{(1 - T_d)} \right] D \]

- \( T_c \) = corporate tax rate.
- \( T_d \) = personal tax rate on debt income.
- \( T_s \) = personal tax rate on stock income.

\[ T_c = 40\%, \ T_d = 30\%, \ \text{and} \ T_s = 12\%. \]

\[ V_L = V_U + \left[ 1 - \frac{(1 - 0.40)(1 - 0.12)}{(1 - 0.30)} \right] D \]

\[ = V_U + (1 - 0.75)D \]

\[ = V_U + 0.25D. \]

Value rises with debt; each $1 increase in debt raises L’s value by $0.25.
Conclusions with Personal Taxes

- Use of debt financing remains advantageous, but benefits are less than under only corporate taxes.
- Firms should still use 100% debt.
- Note: However, Miller argued that in equilibrium, the tax rates of marginal investors would adjust until there was no advantage to debt.

Trade-off Theory

- MM theory ignores bankruptcy (financial distress) costs, which increase as more leverage is used.
- At low leverage levels, tax benefits outweigh bankruptcy costs.
- At high levels, bankruptcy costs outweigh tax benefits.
- An optimal capital structure exists that balances these costs and benefits.

Tax Shield vs. Cost of Financial Distress

[Diagram showing the relationship between the value of a firm, tax shield, distress costs, and debt.]
Signaling Theory

- MM assumed that investors and managers have the same information.
- But, managers often have better information. Thus, they would:
  - Sell stock if stock is overvalued.
  - Sell bonds if stock is undervalued.
- Investors understand this, so view new stock sales as a negative signal.
- Implications for managers?

Pecking Order Theory

- Firms use internally generated funds first, because there are no flotation costs or negative signals.
- If more funds are needed, firms then issue debt because it has lower flotation costs than equity and not negative signals.
- If more funds are needed, firms then issue equity.

Debt Financing and Agency Costs

- One agency problem is that managers can use corporate funds for non-value maximizing purposes.
- The use of financial leverage:
  - Bonds "free cash flow."
  - Forces discipline on managers to avoid perks and non-value adding acquisitions.

(More...)
Debt Financing and Agency Costs

- A second agency problem is the potential for "underinvestment".
- Debt increases risk of financial distress.
- Therefore, managers may avoid risky projects even if they have positive NPVs.

Investment Opportunity Set and Reserve Borrowing Capacity

- Firms with many investment opportunities should maintain reserve borrowing capacity, especially if they have problems with asymmetric information (which would cause equity issues to be costly).

Market Timing Theory

- Managers try to "time the market" when issuing securities.
- They issue equity when the market is "high" and after big stock price run ups.
- They issue debt when the stock market is "low" and when interest rates are "low."
- The issue short-term debt when the term structure is upward sloping and long-term debt when it is relatively flat.
Empirical Evidence

- Tax benefits are important
  - At optimal capital structure, $1 debt adds about $0.10 to $0.20 to value on average.
  - For average firm financed with 25% to 30% debt, this adds about 3% to 6% to the total value.
- Bankruptcies are costly—costs can be up to 10% to 20% of firm value.

Empirical Evidence (Continued)

- Firms have targets, but don’t make quick corrections when stock price changes cause their debt ratios to change.
  - Average speed of adjustment from current capital structure is about 30% per year.
  - Speed is about 50% per year for firms with high cash flow.
  - Speed is about 70% for firms with high cash flow that are above target.

Empirical Evidence (Continued)

- Lost value from being above target is bigger than lost value from being below target.
  - When above target, distress costs rise very rapidly.
  - Sometimes companies will deliberately increase debt to above target to take advantage of unexpected investment opportunity.
Empirical Evidence (Continued)

- After big stock price run ups, debt ratio falls, but firms tend to issue equity instead of debt.
  - Inconsistent with trade-off model.
  - Inconsistent with pecking order.
  - Consistent with windows of opportunity.
- Many firms, especially those with growth options and asymmetric information problems, tend to maintain excess borrowing capacity.

Implications for Managers

- Take advantage of tax benefits by issuing debt, especially if the firm has:
  - High tax rate
  - Stable sales
  - Low operating leverage

Implications for Managers (Continued)

- Avoid financial distress costs by maintaining excess borrowing capacity, especially if the firm has:
  - Volatile sales
  - High operating leverage
  - Many potential investment opportunities
  - Special purpose assets (instead of general purpose assets that make good collateral)
Implications for Managers (Continued)

- If manager has asymmetric information regarding firm’s future prospects, then avoid issuing equity if actual prospects are better than the market perceives.
- Always consider the impact of capital structure choices on lenders’ and rating agencies’ attitudes.

Choosing the Optimal Capital Structure: Example

- \( b = 1.0; r_{RF} = 6\%; R_{P_M} = 6\% \)
- Cost of equity using CAPM:
  - \( r_s = r_{RF} + b (R_{P_M}) = 6\% + 1(6\%) = 12\% \)
- Currently has no debt: \( w_d = 0\% \).
  - WACC = \( r_s = 12\% \).
  - Tax rate is \( T = 40\% \).

Current Value of Operations

- Expected FCF = $30 million.
- Firm expects zero growth: \( g = 0 \).
- \( V_{op} = \frac{[FCF(1+g)]}{(WACC − g)} \)
  - \( = \frac{[$30(1+0)]}{(0.12 − 0)} \)
  - \( = 250 \text{ million} \).
Other Data for Valuation Analysis

- Company has no ST investments.
- Company has no preferred stock.
- 10 million shares outstanding

Current Valuation Analysis

\[
\begin{align*}
V_{\text{op}} & \quad \text{\$250} \\
+ \text{ST Inv.} & \quad 0 \\
V_{\text{Total}} & \quad \$250 \\
- \text{Debt} & \quad 0 \\
S & \quad \$250 \\
\div n & \quad 10 \\
P & \quad \$25.00
\end{align*}
\]

Investment bankers provided estimates of \( r_d \) for different capital structures.

<table>
<thead>
<tr>
<th>( w_d )</th>
<th>0%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r_d )</td>
<td>0.0%</td>
<td>8.0%</td>
<td>8.5%</td>
<td>10.0%</td>
<td>12.0%</td>
</tr>
</tbody>
</table>

If company recapitalizes, it will use proceeds from debt issuance to repurchase stock.
The Cost of Equity at Different Levels of Debt: Hamada’s Formula

- MM theory implies that beta changes with leverage.
- \( b_u \) is the beta of a firm when it has no debt (the unlevered beta)
- \( b = b_u [1 + (1 - T)(w_d/w_e)] \)

The Cost of Equity for \( w_d = 20\% \)

- Use Hamada’s equation to find beta:
  \[
  b = b_u [1 + (1 - T)(w_d/w_e)] \\
  = 1.0 [1 + (1-0.4) (20\% / 80\%)] \\
  = 1.15
  \]
- Use CAPM to find the cost of equity:
  \[
  r_s = r_{RF} + b_L (R_P M) \\
  = 6\% + 1.15 (6\%) = 12.9\%
  \]

The WACC for \( w_d = 20\% \)

- \( WACC = w_d (1-T) r_d + w_e r_s \)
- \( WACC = 0.2 (1 - 0.4) (8\%) + 0.8 (12.9\%) \)
- \( WACC = 11.28\% \)

Repeat this for all capital structures under consideration.
Beta, $r_s$, and WACC

\[
\begin{array}{c|ccccc}
\text{wd} & 0\% & 20\% & 30\% & 40\% & 50\% \\
\hline
r_s & 0.0\% & 8.0\% & 8.5\% & 10.0\% & 12.0\% \\
w_s & 100\% & 80\% & 70\% & 60\% & 50\% \\
b & 1.000 & 1.150 & 1.257 & 1.400 & 1.600 \\
r_s & 12.00\% & 12.90\% & 13.54\% & 14.40\% & 15.60\% \\
WACC & 12.00\% & 11.28\% & \textbf{11.01\%} & 11.04\% & 11.40\%
\end{array}
\]

The WACC is minimized for $w_d = 30\%$. This is the optimal capital structure.

Corporate Value for $w_d = 20\%$

- $V_{op} = \frac{[\text{FCF}(1+g)]}{(WACC - g)}$
  - $V_{op} = \frac{[\$30(1+0)]}{(0.1128 - 0)}$
  - $V_{op} = \$265.96$ million.
- Debt = $D_{New} = w_d \times V_{op}$
  - Debt = $0.20(265.96) = \$53.19$ million.
- Equity = $S = w_s \times V_{op}$
  - Equity = $0.80(265.96) = \$212.77$ million.

Value of Operations, Debt, and Equity

\[
\begin{array}{c|ccccc}
\text{wd} & 0\% & 20\% & 30\% & 40\% & 50\% \\
\hline
r_s & 0.0\% & 8.0\% & 8.5\% & 10.0\% & 12.0\% \\
w_s & 100\% & 80\% & 70\% & 60\% & 50\% \\
b & 1.000 & 1.150 & 1.257 & 1.400 & 1.600 \\
r_s & 12.00\% & 12.90\% & 13.54\% & 14.40\% & 15.60\% \\
WACC & 12.00\% & 11.28\% & 11.01\% & 11.04\% & 11.40\% \\
V_{op} & \$250.00 & \$265.96 & \textbf{\$272.48} & \$271.74 & \$263.16 \\
D & \$0.00 & \$53.19 & \$61.74 & \$108.70 & \$131.58 \\
S & \$250.00 & \$212.77 & \$190.74 & \$163.04 & \$131.58
\end{array}
\]

Value of operations is maximized at $w_d = 30\%$. 

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Anatomy of a Recap: Before Issuing Debt

Before Debt

\[ V_{00} \] $250

+ ST Inv. 0

\[ V_{\text{Total}} \] $250

− Debt 0

\[ S \] $250

÷ \[ n \] 10

\[ P \] $25.00

Total shareholder wealth: \[ S + \text{Cash} \] $250

Issue Debt (\( w_d = 20\% \)), But Before Repurchase

- WACC decreases to 11.28%.
- \( V_{op} \) increases to $265.9574.
- Firm temporarily has short-term investments of $53.1915 (until it uses these funds to repurchase stock).
- Debt is now $53.1915.

Anatomy of a Recap: After Debt, but Before Repurchase

Before Debt

\[ V_{00} \] $250

+ ST Inv. 0

\[ V_{\text{Total}} \] $250

− Debt 0

\[ S \] $250

÷ \[ n \] 10

\[ P \] $25.00

After Debt, Before Rep.

\[ V_{00} \] $265.96

+ ST Inv. 53.19

\[ V_{\text{Total}} \] $319.15

− Debt 53.19

\[ S \] $265.96

÷ \[ n \] 10

\[ P \] $26.60

Total shareholder wealth: \[ S + \text{Cash} \] $265.96
After Issuing Debt, Before Repurchasing Stock

- Stock price increases from $25.00 to $26.60.
- Wealth of shareholders (due to ownership of equity) increases from $250 million to $265.96 million.

The Repurchase: No Effect on Stock Price

- The announcement of an intended repurchase might send a signal that affects stock price, and the previous change in capital structure affects stock price, but the repurchase itself has no impact on stock price.
  - If investors thought that the repurchase would increase the stock price, they would all purchase stock the day before, which would drive up its price.
  - If investors thought that the repurchase would decrease the stock price, they would all sell short the stock the day before, which would drive down the stock price.

Remaining Number of Shares After Repurchase

- $D_{\text{Old}}$ is amount of debt the firm initially has, $D_{\text{New}}$ is amount after issuing new debt.
- If all new debt is used to repurchase shares, then total dollars used equals
  - $(D_{\text{New}} - D_{\text{Old}}) = ($53.19 - $0) = $53.19.
- $n_{\text{Prior}}$ is number of shares before repurchase, $n_{\text{Post}}$ is number after. Total shares remaining:
  - $n_{\text{Post}} = n_{\text{Prior}} - (D_{\text{New}} - D_{\text{Old}})/P$
  - $= 10 - ($53.19/$26.60) = 8$ million.

(Ignore rounding differences; see Ch15 Mini Case.xlsx for actual calculations).
Anatomy of a Recap: After Repurchase

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{0}$</td>
<td>$250</td>
<td>$265.96</td>
<td>$265.96</td>
</tr>
<tr>
<td>$+ ST Inv.$</td>
<td>0</td>
<td>53.19</td>
<td>0</td>
</tr>
<tr>
<td>$V_{Total}$</td>
<td>$250</td>
<td>$319.15</td>
<td>$265.96</td>
</tr>
<tr>
<td>$- Debt$</td>
<td>0</td>
<td>53.19</td>
<td>53.19</td>
</tr>
<tr>
<td>$S$</td>
<td>$250</td>
<td>$265.96</td>
<td>$212.77</td>
</tr>
<tr>
<td>$÷ n$</td>
<td>10</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>$P$</td>
<td>$25.00</td>
<td>$26.60</td>
<td>$26.60</td>
</tr>
</tbody>
</table>

Total shareholder wealth: $S + Cash

Key Points

- ST investments fall because they are used to repurchase stock.
- Stock price is unchanged.
- Value of equity falls from $265.96 to $212.77 because firm no longer owns the ST investments.
- Wealth of shareholders remains at $265.96 because shareholders now directly own the funds that were held by firm in ST investments.

Intrinsic Stock Price Maximized at Optimal Capital Structure

<table>
<thead>
<tr>
<th>$w_d$</th>
<th>0%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_d$</td>
<td>0.0%</td>
<td>8.0%</td>
<td>8.5%</td>
<td>10.0%</td>
<td>12.0%</td>
</tr>
<tr>
<td>$w_s$</td>
<td>100%</td>
<td>80%</td>
<td>70%</td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>$b$</td>
<td>1.000</td>
<td>1.150</td>
<td>1.257</td>
<td>1.400</td>
<td>1.600</td>
</tr>
<tr>
<td>$r_s$</td>
<td>12.00%</td>
<td>12.90%</td>
<td>13.54%</td>
<td>14.40%</td>
<td>15.60%</td>
</tr>
<tr>
<td>WACC</td>
<td>12.00%</td>
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<td>11.01%</td>
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<td>11.40%</td>
</tr>
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<td><strong>$272.48</strong></td>
<td>$271.74</td>
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</tr>
<tr>
<td>$D$</td>
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<tr>
<td>$S$</td>
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<td>$212.77</td>
<td>$190.74</td>
<td>$163.04</td>
<td>$131.58</td>
</tr>
<tr>
<td>$n$</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>$P$</td>
<td>$25.00</td>
<td>$26.60</td>
<td><strong>$27.25</strong></td>
<td>$27.17</td>
<td>$26.32</td>
</tr>
</tbody>
</table>
Shortcuts

- The corporate valuation approach will always give the correct answer, but there are some shortcuts for finding S, P, and n.
- Shortcuts on next slides.

Calculating S, the Value of Equity after the Recap

- \( S = (1 - w_d) V_{op} \)
- At \( w_d = 20\% \):
  - \( S = (1 - 0.20) \times $265.96 \)
  - \( S = $212.77 \).

Number of Shares after a Repurchase, \( n_{Post} \)

- At \( w_d = 20\% \):
  - \( n_{Post} = n_{Prior} \times \frac{V_{opNew} - D_{New}}{V_{opNew} - D_{Old}} \)
    - \( = 10 \times \frac{$265.96 - $53.19}{$265.96 - $0} \)
    - \( = 8 \)
Calculating $P_{Post}$ the Stock Price after a Recap

- At $w_d = 20\%$
- $P_{Post} = (V_{opNew} - D_{Old})/n_{Prior}$
- $= ($265.96 - $0)/10$
- $= $26.60

Optimal Capital Structure

- $w_d = 30\%$ gives:
  - Highest corporate value
  - Lowest WACC
  - Highest stock price per share
- But $w_d = 40\%$ is close. Optimal range is pretty flat.

What if L's debt is risky?

- If L's debt is risky then, by definition, management might default on it. The decision to make a payment on the debt or to default looks very much like the decision whether to exercise a call option. So the equity looks like an option.
Equity as an option

- Suppose the firm has $2 million face value of 1-year zero coupon debt, and the current value of the firm (debt plus equity) is $4 million.

- If the firm pays off the debt when it matures, the equity holders get to keep the firm. If not, they get nothing because the debtholders foreclose.

Equity as an option

- The equity holder's position looks like a call option with
  - $P = $4 million
  - $X = $2 million
  - $t = 1 year
  - Suppose $r_{RF} = 6\%$
  - $\sigma = 0.60$

Use Black-Scholes to price this option

$$V_c = P[N(d_1)] - Xe^{-r_{RF}t}N(d_2)$$

$$d_1 = \frac{\ln(P/X) + [r_{RF} + (\sigma^2/2)]t}{\sigma \sqrt{t}}$$

$$d_2 = d_1 - \sigma t^{0.5}$$
Black-Scholes Solution

\[ V = 4[N(d_1)] - 2e^{-(0.06)(1.0)} [N(d_2)]. \]

\[ d_1 = \frac{\ln(4/2) + [(0.06 + 0.36/2)(1.0)]}{(0.60)(1.0)} = 1.5552. \]

\[ d_2 = d_1 - (0.60)(1.0) = d_1 - 0.60 = 1.5552 - 0.6000 = 0.9552. \]

\[ \begin{align*}
N(d_1) &= N(1.5552) = 0.9401 \\
N(d_2) &= N(0.9552) = 0.8383 \\
\text{Note: Values obtained from Excel using NORMSDIST function.}
\end{align*} \]

\[ V = 4(0.9401) - 2e^{-0.06(0.8303)} = 3.7604 - 2(0.9418)(0.8303) = 2.196 \text{ Million} = \text{Value of Equity} \]

Value of Debt

- The value of debt must be what is left over:

\[ \text{Value of debt} = \text{Total Value} - \text{Equity} = 4 \text{ million} - 2.196 \text{ million} = 1.804 \text{ million} \]
This value of debt gives us a yield

- Debt yield for 1-year zero coupon debt
  \[ = \frac{\text{face value}}{\text{price}} - 1 \]
  \[ = \frac{\$2\text{ million}}{1.804\text{ million}} - 1 \]
  \[ = 10.9\% \]

How does \( \sigma \) affect an option's value?

- Higher volatility \( \sigma \) means higher option value.

Managerial Incentives

- When an investor buys a stock option, the riskiness of the stock (\( \sigma \)) is already determined. But a manager can change a firm's \( \sigma \) by changing the assets the firm invests in. That means changing \( \sigma \) can change the value of the equity, even if it doesn't change the expected cash flows:
Managerial Incentives

- So changing $\sigma$ can transfer wealth from bondholders to stockholders by making the option value of the stock worth more, which makes what is left, the debt value, worth less.

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Value of Debt and Equity for Different Volatilities

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Bait and Switch

- Managers who know this might tell debtholders they are going to invest in one kind of asset, and, instead, invest in riskier assets. This is called bait and switch and bondholders will require higher interest rates for firms that do this, or refuse to do business with them.
How do companies manage the maturity structure of their debt?

- Maturity matching
  - Finance long-term assets with long-term debt
  - Finance short-term assets with short-term debt.
- Information asymmetries: Firms with better future prospects than expected by investors
  - Issuing long-term debt will lock in a higher interest rate than warranted by company’s prospect.
  - So issue short-term debt (even though its rate is too high) but refinance at appropriate rate when company’s prospects are revealed.