The Relationship between Capital Structure and Operational Characteristics

John R. Birge
The University of Chicago Graduate School of Business

www.ChicagoGSB.edu/fac/john.birge
Themes

• The traditional tradeoff and pecking order theories differ in the assumed relationship between profitability and leverage
• Traditional analyses do not recognize the lag between purchasing commitment and product/service revenues
• Incorporating the lag into a tradeoff model can reverse profitability-leverage relationship
• An expanded tradeoff model with lag (as in news vendor) produces a relationship that is supported empirically in the cross-section of firms
Outline

• Basic theories of capital structure
• Model with commitment and lagged revenue
• Predictions of the model
• Empirical results
• Conclusions
Capital Structure Theories

• **Tradeoff (Modigliani/Miller)**
  – Without market imperfections, firms are indifferent among capital structures (debt vs. equity)
  – Firms trade off the tax advantage of debt and the costs of financial distress to obtain an optimal capital structure

• **Implications**
  – Firms with higher profitability can support more debt and, therefore, should have higher market leverage (ratio of debt to the value of the firm)
Pecking Order Theory

• Agency Effects (Myers/Majluf)
  – Firms have private information that is signaled to the market through capital structure
  – Firms prefer first to use internal funds, followed by debt and then equity to finance investments

• Results
  – As firm profitability increases, firms use less debt and should have lower market leverage
Tradeoff Revisited

• Missing elements
  – Debt capacity of the firm is determined by expectations of future repayment capability which depends on current decisions
  – Time lag exists between purchasing commitments and realization of revenues
Model with Time Lag

- State: inventory (scale) position at t: $z_t$; cash at t: $k_t$
- Value: $V_t(z_t)$
- Decisions: Production ($x_t$), Equity ($E_t$) and Debt ($D_t$)
- Costs: Fixed ($K_t$), Variable Production ($c_t$), Holding ($h_t$)
- Selling price (fixed/competitive): $p_t$
- Risk-neutral-equivalent demand dist: $F_t$
- Dividends (positive or negative): $d_t$
- Risk-free discount factor: $\beta_t$
- Rate on debt: $r_t$
- Default (bankruptcy) point: $b_t$
- Breakeven (positive net income) point: $e_t$
- Recovery fraction: $\alpha$
- Tax rate: $\tau$
Decision Structure

- Period t Value, $V_t(k_t, z_t) = \max \{0, d_t + \beta_t \left[ \left( \int_0^{b_t} \alpha p_t s dF_t(s) \right) + \int_{b_t}^{e_t} (V_{t+1}(p_t s - D_t(1+r_t), x_t + z_t - s)) dF_t(s) \right. \}
+ \left. \left( \int_{e_t}^{\infty} xt + z_t (V_{t+1}((1-\tau) p_t s + \tau(K_t + c_t x_t + h_t z_t + r_t D_t) - D_t(1+r_t), x_t + z_t - s)) dF_t(s) \right) \right\}
+ \int_{x_t + z_t}^{\infty} (V_{t+1}((1-\tau) p_t (x_t + z) + \tau(K_t + c_t x_t + h_t z_t + r_t D_t) - D_t(1+r_t), 0)) dF_t(s)) \}

subject to:

$K_t + c_t x_t + h_t z + d_t \leq k_t + D_t$

$D_t = \beta_t \left( \int_0^{b_t} \alpha p_t s dF_t(s) + D_t(1+r_t) \int_{b_t}^{\infty} dF_t(s) \right)$

$x_t \geq 0$

Note: Debt paid at end of period (if not in default)
Observations: Variable Costs

- Results in single period and multi-period with no fixed costs (Xu/JRB):
  - As margin increases, market leverage ($D_t/V_t$) is convex function of profit margin ($(p_t-c_t)/p_t$)
  - Initially, leverage decreases with increasing profit margin, but may eventually increase with high margins

- Explanation: at low margins, order point is low quantile of distribution; small increases lead to large increases in risk; hence, more costly debt
Fixed Cost Effects

• As fixed cost increases, the order quantile only changes through changes in bankruptcy point

• Overall effect is that increasing fixed cost, should raise breakeven point and lower the advantage of debt

• Net effect is that debt is decreasing as fixed costs increase
Net Income Predictions

• High Fixed Cost Firms:
  – Possible net losses
  – Higher net losses should have low leverage

• Low Fixed Cost Firms:
  – Should have positive net income
  – Higher net income should have convex relation to leverage as in variable-cost case
Predictions on Net Operating Margin

Leverage

High Fixed

Low Fixed

Total

Profit Margin

© JRBirge
INFORMS National Meeting, Seattle, November 2007
Other Predictions

- Inventory variation should be increasing in net income for firms with low fixed costs
- Variable effects should be larger in industries with lower capital costs
- For firms with high fixed costs and significant losses, inventory variation may also be high due to high volatility in potential revenues
Empirical Results

• Datasets:
  – Value line (Damodoran)
  – Compustat (CRSP)

• Approach
  – Cross-section of firms in years 1997-2006
  – Sort net operating margin by decile
  – Compare test statistics on neighboring deciles for market leverage and inventory
  – Group by industry
### US 2006 Valueline Data

<table>
<thead>
<tr>
<th>Dec</th>
<th>Market debt to capital average</th>
<th>Standard Deviation</th>
<th>Number of Observations</th>
<th>Test Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16.72%</td>
<td>24.78%</td>
<td>561</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>21.02%</td>
<td>29.10%</td>
<td>561</td>
<td>2.665023773</td>
</tr>
<tr>
<td>3</td>
<td>26.24%</td>
<td>31.75%</td>
<td>561</td>
<td>2.871519799</td>
</tr>
<tr>
<td>4</td>
<td>22.68%</td>
<td>25.72%</td>
<td>561</td>
<td>-2.06665712</td>
</tr>
<tr>
<td>5</td>
<td>20.39%</td>
<td>24.86%</td>
<td>561</td>
<td>-1.51216097</td>
</tr>
<tr>
<td>6</td>
<td>18.94%</td>
<td>22.45%</td>
<td>561</td>
<td>-1.027931</td>
</tr>
<tr>
<td>7</td>
<td>16.88%</td>
<td>19.13%</td>
<td>561</td>
<td>-1.6538986</td>
</tr>
<tr>
<td>8</td>
<td>16.02%</td>
<td>19.49%</td>
<td>561</td>
<td>-0.74542612</td>
</tr>
<tr>
<td>9</td>
<td>17.19%</td>
<td>21.30%</td>
<td>561</td>
<td>0.956639437</td>
</tr>
<tr>
<td>10</td>
<td>21.60%</td>
<td>23.45%</td>
<td>560</td>
<td>3.300478465</td>
</tr>
</tbody>
</table>
Valueline 2006 Chart

• Market leverage of pre-tax operating margin deciles
## Compustat 1997-2006 Inventory Coefficient of Variation

- **Deciles of Pre-Tax Operating Margin**

<table>
<thead>
<tr>
<th>Decile</th>
<th>CoV of Inventory</th>
<th>StDev</th>
<th>Test Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.157247914</td>
<td>1.111810981</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.55323907</td>
<td>0.515866409</td>
<td>-6.07568388</td>
</tr>
<tr>
<td>3</td>
<td>0.440673247</td>
<td>0.531052454</td>
<td>-1.874496486</td>
</tr>
<tr>
<td>4</td>
<td>0.48420371</td>
<td>0.574858448</td>
<td>0.685755807</td>
</tr>
<tr>
<td>5</td>
<td>0.466916211</td>
<td>0.638301832</td>
<td>-0.248117683</td>
</tr>
<tr>
<td>6</td>
<td>0.413530761</td>
<td>0.430010879</td>
<td>-0.855184239</td>
</tr>
<tr>
<td>7</td>
<td>0.575409454</td>
<td>0.747602996</td>
<td>2.314076304</td>
</tr>
<tr>
<td>8</td>
<td>0.533757565</td>
<td>0.472743771</td>
<td>-0.580554414</td>
</tr>
<tr>
<td>9</td>
<td>0.644108778</td>
<td>0.564039466</td>
<td>1.848624373</td>
</tr>
<tr>
<td>10</td>
<td>1.080029368</td>
<td>1.008333751</td>
<td>4.65166548</td>
</tr>
</tbody>
</table>
Industry Results

• Results for all industries show initial increase in leverage followed by decrease in leverage as margins increase

• Results for some industry sectors (esp. financial services) also show increase in leverage for very high margin
Conclusions

• Including lags between commitment and realization of revenues can make tradeoff models consistent with empirical observations

• Models also appear to give consistent predictions for variation in inventory levels

• Pecking order may still be in effect but may also be consistent with tradeoff theory