A Theory of Debt Maturity: The Long and Short of Debt Overhang

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Discussion by Michal Szkup

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Debt Overhang

- What is debt overhang problem?

Consider a firm that issued in the past risky debt and has now an option to undertake an investment with positive Net Present Value (NPV); If the firm undertakes the investment a part of the future cash flows it generates from will potentially go to debt holders; In particular if the firm defaults all of the cash flows from the investment will go to debt holders; This truncation of cash flows may lead to underinvestment; In particular, the firm may choose not to undertake investment unless NPV is high enough; Underinvestment caused by the existing debt is called a debt overhang problem; First pointed out and analyzed by Myers (1977);
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- At $t = 1$ it has an option to invest which requires $I$ of funds;
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- Consider a firm that has no asset in place at \( t = 0 \);
- At \( t = 1 \) it has an option to invest which requires \( I \) of funds;
- Payoff of investment is \( V(s) \) and it accrues in the same period;
- If the firm is fully equity financed then it will invests as long as \( V(s) \geq I \);
Now suppose that the firm has an existing debt with face value $P$ maturing at $t = 1$. Then the firm will invest if $V(s) > I + P$. If $V(s) < I + P$, the firm defaults at $t = 1$ and debt-holders take over. They will exercise the option to invest if $V(s) > I$. No ine¢ cient underinvestment.
Example Continued

- Now suppose that the firm has an existing debt with face value $P$ maturing at $t = 1$
- Then the firm will invest iff $V(s) \geq I + P$
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- Now suppose that the firm has an existing debt with face value $P$ maturing at $t = 2$;
Example Continued

- Now suppose that the firm has an existing debt with face value \( P \) maturing at \( t = 1 \).
- Then the firm will invest iff \( V(s) \geq I + P \).
- If \( V(s) < I + P \) the firm defaults at \( t = 1 \) and debt-holders take over.
- They will exercise the option to invest if \( V(s) \geq I \).
- No inefficient underinvestment.
- Now suppose that the firm has an existing debt with face value \( P \) maturing at \( t = 2 \).
- Again, the firm will invest iff \( V(s) \geq I + P \).
Example Continued

- Now suppose that the firm has an existing debt with face value \( P \) maturing at \( t = 1 \)
- Then the firm will invest iff \( V(s) \geq I + P \)
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- Again, the firm will invest iff \( V(s) \geq I + P \)
- If \( V(s) < I + P \) the firm doesn’t invest and defaults at \( t = 2 \)
Example Continued

- Now suppose that the firm has an existing debt with face value $P$ maturing at $t = 1$
- Then the firm will invest iff $V(s) \geq I + P$
- If $V(s) < I + P$ the firm defaults at $t = 1$ and debt-holders take over
- They will exercise the option to invest if $V(s) \geq I$
- No inefficient underinvestment

- Now suppose that the firm has an existing debt with face value $P$ maturing at $t = 2$;
- Again, The the firm will invest iff $V(s) \geq I + P$
- If $V(s) < I + P$ the firm doesn’t invest and defaults at $t = 2$
- Therefore for $V(s) \in [I, I + P)$ profitable investment is forgone
Motivation

- The example above suggests that a solution to the debt overhang problem is short-term debt;
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  - argues that this is because short-term debt can also lead to the debt overhang.
Motivation

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- If that’s true then the firms with "growth opportunities" should borrow short-term;
- The empirical evidence though are mixed;
- This paper:
  - argues that this is because short-term debt can also lead to the debt overhang;
  - shows that in some cases short-term debt might impose stronger debt overhang than the long-term debt.
The Model

- There are four periods $t = -1, 0, 1, 2$
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- The firm defaults if it cannot repay the maturing debt.
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- At $t = 1$ the firm needs to roll over the short-term debt
- At $t = 2$ the investments mature and firm pays off its debt
- The firm defaults if it cannot repay the maturing debt.
- There is a covenant saying that any new financing is *junior* to the existing long-term debt.
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- At $t = 0$ the firm learns whether the overall state is *Good* ($G$) or *Bad* ($B$);
- Then the state evolves according to binomial tree and can go either *up* or *down*;
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Investment in state $G$ has NPV of $\gamma^G$ while in state $B$ the NPV is $\gamma^B$.
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- Then the state evolves according to binomial tree and can go either up or down;
- Investment in state $G$ has NPV of $\gamma^G$ while in state $B$ the NPV is $\gamma^B$;
- It is financed by issuing equity;
- If the firm defaults the debt holders receive the value of the assets in place;
Solving the model (state $G$)

- Payoffs in state $G$:

  \[
  \begin{align*}
  \text{Gu} & 
  \quad 0.5 
  \quad \rightarrow \quad Guu 
  \quad 2X^G + Y^G \\
  \text{Gd} & 
  \quad 0.5 
  \quad \rightarrow \quad Gdd 
  \quad 0 + Y^G \\
  \text{Gd} & 
  \quad 0.5 
  \quad \rightarrow \quad Gdu 
  \quad X^G + Y^G \\
  \text{G} & 
  \quad 0.5 
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  \end{align*}
  \]
Solving the model (state $G$)

- Payoffs in state $G$:

  $G$
  
  $\begin{array}{c}
  G_1 \downarrow \nonumber \\
  G_2 \downarrow \nonumber \\
  G_3 \downarrow \nonumber \\
  G_4 \downarrow \nonumber \\
  G_5 \downarrow \nonumber \\
  G_6 \downarrow \\
  \end{array}$

  $\begin{array}{c}
  Gu \quad 0.5 \quad 2X^G + Y^G \\
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  Gd \downarrow \nonumber \\
  Gdd \quad 0 + Y^G \\
  \end{array}$

- We assume that $X^G > 2F_1 + F_2$ and $Y^G > F_2$. 
Solving the model (state G)

- At $t = 1$ short-term debt can be always rolled over implying that it is riskless.

This implies that the value of debt issued at $t = 1$ in state $G$ is:

$$\begin{align*}
    & IF_1 + 34F_2 \text{ if no investment at } t = 0 \\
    & IF_1 + F_2 \text{ if there is investment at } t = 0
\end{align*}$$

Hence investment at $t = 0$ leads to a transfer of $14F_2$ to long-term debt holders. Therefore the firm will invest if $\gamma_{G} > 14F_2$.

The standard debt overhang problem.
Solving the model (state G)

- At $t = 1$ short-term debt can be always rolled over implying that it is riskless.
- However, long-term debt is risky because at state $Gdd$, without extra investment firm will default.
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- At $t = 1$ short-term debt can be always rolled over implying that it is riskless.
- However, long-term debt is risky because at state $Gdd$, without extra investment firm will default.
- This implies that the value of debt issued at $t = -1$ in state $G$ is:

$$
\begin{align*}
\text{IF} & \\
\text{IF} & \frac{1}{4}F_2 & \text{if no investment at } t = 0 \\
\text{IF} & F_2 & \text{if there is investment at } t = 0
\end{align*}
$$

Hence investment at $t = 0$ leads to a transfer of $\frac{1}{4}F_2$ to long-term debt holders. Therefore the firm will invest if $\gamma G \frac{1}{4}F_2$.
Solving the model (state $G$)

- At $t = 1$ short-term debt can be always rolled over implying that it is riskless.
- However, long-term debt is risky because at state $G_{dd}$, without extra investment firm will default.
- This implies that the value of debt issued at $t = -1$ in state $G$ is:
  - $F_1 + \frac{3}{4}F_2$ if no investment at $t = 0$
Solving the model (state G)

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- However, long-term debt is risky because at state $Gdd$, without extra investment firm will default.
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  - $F_1 + F_2$ if there is investment at $t = 0$
- Hence investment at $t = 0$ leads to a transfer of $\frac{1}{4}F_2$ to long-term debt holders
- Therefore the firm will invests iff $\gamma^G \geq \frac{1}{4}F_2$
Solving the model (state $G$)

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- Hence investment at $t = 0$ leads to a transfer of $\frac{1}{4} F_2$ to long-term debt holders.

- Therefore the firm will invests iff $\gamma^G \geq \frac{1}{4} F_2$

- The standard debt overhang problem.
Solving the model (state $B$)

- Payoffs in state $B$:

```
\begin{align*}
\text{Bu} & : 2X^B + Y^B \\
\text{Bud} & : X^B + Y^B \\
\text{Bdd} & : 0 + Y^B
\end{align*}
```
Solving the model (state B)

- Payoffs in state $B$:

  - $B_{uu}$: $0.5 \cdot 2X^B + Y^B$
  - $B_{ud}$: $0.5 \cdot X^B + Y^B$
  - $B_{du}$: $0.5 \cdot X^B + Y^B$
  - $B_{dd}$: $0 + Y^B$

- We assume that $X_B < 2F_1 + F_2$ and $\frac{3}{2}X_B > F_1 + F_2$
Solving the model (state B)

- Payoffs in state B:

- We assume that $X_B < 2F_1 + F_2$ and $\frac{3}{2}X_B > F_1 + F_2$
- Furthermore: $X_B + Y_B > 2F_1 + F_2$
It follows then that the value of debt issued at $t = -1$ at state $B$: 
State B

- It follows then that the value of debt issued at $t = -1$ at state $B$:
  - $\frac{1}{2} F_1 + \frac{1}{2} F_2 + \frac{1}{4} X_B$ w/o investment
State B

- It follows then that the value of debt issued at $t = -1$ at state $B$:
  - $\frac{1}{2} F_1 + \frac{1}{2} F_2 + \frac{1}{4} X_B$ w/o investment
  - $F_1 + F_2$ w/ investment if $Y_B \geq F_2$
It follows then that the value of debt issued at $t = -1$ at state $B$: 

- $\frac{1}{2} F_1 + \frac{1}{2} F_2 + \frac{1}{4} X_B$ without investment
- $F_1 + F_2$ with investment if $Y_B \geq F_2$
- $F_1 + \frac{3}{4} F_2 + \frac{1}{4} Y_B$ with investment if $Y_B < F_2$
State B

- It follows then that the value of debt issued at $t = -1$ at state $B$:
  - $\frac{1}{2} F_1 + \frac{1}{2} F_2 + \frac{1}{4} X_B$ w/o investment
  - $F_1 + F_2$ w/ investment if $Y_B \geq F_2$
  - $F_1 + \frac{3}{4} F_2 + \frac{1}{4} Y_B$ w/ investment if $Y_B < F_2$

- The transfer to debt holders is $\frac{1}{2} F_1 + \frac{1}{2} F_2 - \frac{1}{4} X_B$ or
  $\frac{1}{2} \left( F_1 + \frac{F_2}{2} \right) + \frac{Y_B}{4} - \frac{X_B}{4}$
It follows then that the value of debt issued at $t = -1$ at state $B$:

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The firm then invests iff $\gamma_B$ is greater than that transfer.
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This is due to two effects:

- an increase in leverage - when firms assets are worth less investment will lead to greater transfer to debt holders (this is true for both types of debt)

- high refinancing cost because little uncertainty is resolved between $t=0$ and $t=1$;

Long-term debt holders share both losses and gains with the firm. Short-term debt holders is a “hard claim” and is similar to down-and-out option.
Comments:

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- This is due to two effects:
  
  - An increase in leverage - when firms' assets are worth less investment will lead to greater transfer to debt holders (this is true for both types of debt).
  
  - A high refinancing cost because little uncertainty is resolved between $t = 0$ and $t = 1$.
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Long-term debt holders share both losses and gains with the firm.

Short-term debt holders is a "hard claim" and is similar to down-and-out option.
The firm is choosing debt maturity \((F_1, F_2)\) to minimize overhang.
Model Solution

- The firm is choosing debt maturity \((F_1, F_2)\) to minimize overhang.
- Minimizing debt overhang requires

\[
I_F^2 < 4\gamma G \text{ (investment at } G) \quad I_F^2 > Y_B 	ext{ and } F_1^2 \gamma B + 1^2 Y_B 1^2 F_2
\]
Model Solution

- The firm is choosing debt maturity \((F_1, F_2)\) to minimize overhang.
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  - \(F_2 < 4\gamma^G\) (investment at \(G\))
  - \(F_2 > Y_B\) and \(F_1 \leq 2\gamma^B + \frac{1}{2} Y^B - \frac{1}{2} X_B - \frac{1}{2} F_2\)
Model Solution

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- Minimizing debt overhang requires
  - \(F_2 < 4\gamma^G\) (investment at \(G\))
  - \(F_2 > Y_B\) and \(F_1 \leq 2\gamma^B + \frac{1}{2}Y^B - \frac{1}{2}X_B - \frac{1}{2}F_2\)

\[
D^{-1} = F_1 + \frac{3F_2 + Y^B}{4}
\]

\[
D^{-1} = F_1 + F_2
\]
Conclusion

- We saw that:
  - At the heart of the problem lies the wealth transfer to the debt holders.
  - Risky long-term debt imposes debt overhang both when asset-in-place are of high and low value.
  - Risky short-term debt imposes no overhang when assets in-place are of high values but has strong overhang effect when their value is low.

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- Risky long-term debt can impose debt overhang both when asset-in-place are of high and low value
- Risky short-term debt imposes no overhang when assets in place-in-place are of high values
Conclusion

We saw that:

- At the heart of the problem lies the wealth transfer to the debt holders
- Risky long-term debt can imposes debt overhang both when asset-in-place are of high and low value
- Risky short-term debt imposes no overhang when assets in place-in-place are of high values
- But has strong overhang effect when their value is low
Appendix - different timings

<table>
<thead>
<tr>
<th>$R&amp;Inv / state$</th>
<th>$Gu$</th>
<th>$Gd$</th>
<th>$Bu$</th>
<th>$Bd$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t = 0 \ t = 1$</td>
<td>0</td>
<td>$\frac{1}{2} F_2$</td>
<td>0</td>
<td>$\frac{2}{3} F_2 + \frac{2}{3} F_1 + \frac{1}{3} Y_B - \frac{1}{2} X_B$</td>
</tr>
<tr>
<td>$t = 1 \ t = 1$</td>
<td>0</td>
<td>$\frac{1}{2} F_2$</td>
<td>0</td>
<td>$F_1 + F_2 - \frac{1}{2} X_B$</td>
</tr>
</tbody>
</table>

where we assumed that there is default without new investment in the case (0, 0)