Maturity Overhang: Evidence from M&A
Chen, Hackbarth, Harford & Luo

Harjoat S. Bhamra

Imperial College Business School

2025

Rolling over maturing debt: what happens?

- Whenever a firm's debt comes due, it has two basic choices:
  1. Pay it down in cash
  2. Refinance ("roll over") by issuing new debt
- In practice, most firms do 2 to avoid a large one-off cash outlay.
- What happens in a small time interval dt, if the firm's total long-term debt has par value P and average remaining maturity M (assumed to be constant)?

How do Roll-Over Losses Arise?

1. A fraction dt/M of the debt principal matures
   - Amount due: $\frac{P}{M}dt$.
2. The firm issues new bonds to replace that maturing slice
   - Par amount issued: $\frac{P}{M}dt$ (to keep total par at P).
   - Proceeds received: $(1-\kappa)\frac{D(W)}{M}dt$, where
   - $\kappa =$ proportional issuance cost
   - $D(W) =$ market value of the firm's debt (a function of its cash W)
3. Net cash impact (rollover gain or loss)
   - If proceeds $(1-\kappa)D(W)/M$ are less than the principal that must be repaid P/M, the firm makes a rollover loss – often has to top up the difference from its cash reserves:

$$L(W) = \frac{1}{M}[P - (1-\kappa)D(W)]$$

   - L is the rollover loss per unit time.

Research Question

- How do fluctuations in rollover losses – via the interaction of short debt maturities and corporate bond prices – create a **maturity overhang** that distorts large investment decisions, specifically **mergers and acquisitions**?

$$L(W) = \frac{1}{M}[P - (1-\kappa)D(W)]$$

- When firms must roll over maturing debt at market prices below par, does the resulting rollover risk dampen M&A activity, bias payment choices, and influence stock-market reactions?

Why do we care?

- Classic debt overhang (Myers 1977) arises from long-dated debt that discourages new investment
- Diamond and He (2014): short maturities can worsen underinvestment because frequent rollovers at a discount deplete cash and raise default risk.
- this paper: M&A is among the most visible, lump-sum investments firms make; understanding how debt-market conditions shape M&A has implications for corporate financing, investment efficiency, and market regulation.

Paper Summary

- **Theoretical Contributions (beyond Diamond & He (2014)):**
  - Focus on M&A
  - Firms can use cash to pay for acquisitions, not just equity
  - Hypotheses tested in this paper cannot be tested within framework of Diamond & He (2014)
- **Empirical Tests of Theory:**
  - Hypothesis I: Firms facing higher market-based rollover risk (and/or shorter average debt maturity) are less likely to initiate an acquisition in a given year.
  - Hypothesis II. Conditional on doing a deal, firms with higher rollover risk (and/or shorter maturity) are less likely to pay 100% cash.
  - Hypothesis III. The positive "cash-premium" in acquirer's cumulative abnormal returns is is only present when rollover risk is low (or maturity is long).

Comments & Suggestions

- Comments
  - Empirical work clearly novel relative to literature: first paper to show how rollover risk from short term debt impacts M&A activity and acquirer returns
  - Authors do not identify a clear theoretical contribution relative to Diamond & He (2014).
  - Large risk the theory will be seen as minor extension of Diamond & He (2014) more mathematical complexity, but no novel economic ideas.
- Suggestions
  - Clearly explain theoretical contribution relative to Diamond & He (2014)
  - If possible, prove important statements to support the novel theoretical contribution.
  - Exploit the model to empirically assess the quantitative importance of this theoretical contribution.

Remainder of this discussion

- Model Overview
- Comparison with Diamond & He (2014)
- My view on the theoretical contribution relative to Diamond & He (2014)
- Development of new theoretical results required to assess the quantitative importance of the novel theoretical contribution.

Model: Capital and Cash

- Evolution of after-tax cashflows

$$dW_t = (1-\theta)\left[K^{\alpha}\left(\mu dt + \sigma dZ_t\right) + G dt\right] - L(W_t)dt$$

- Pre-merger: $K = \underline{K}$, $G = 0$
- Post-merger: $K = \overline{K}$, $G > 0$
- Post - merger: more expected growth and more risk

Corporate Bond Prices

- No arbitrage implies bond price $D(W)$ given by

$$0 = \frac{1}{2}D''(W)E_t\left[\frac{(dW_t)^2}{dt}\right] + D'(W_t)\left[(r-\lambda)W_t - C + E_t\left[\frac{dW_t}{dt}\right]\right]$$
$$-\left(r+\frac{1}{M}\right)D\left(W_t\right) + C + \frac{P}{M}$$

- Structure of the ode contains hints about the theoretical contribution
- Need better understanding of economics hidden inside the rollover loss term in $E_t\left[\frac{dW_t}{dt}\right]$

$$E_t\left[\frac{dW_t}{dt}\right] = (1-\theta)\left(K^\alpha\mu + G\right)dt - L(W_t)dt$$

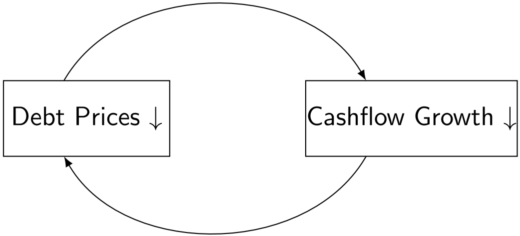
where

$$L(W) = \frac{1}{M}[P-(1-\kappa)D(W)]$$

Novel Amplification Mechanism

- Rollover losses reduce growth rate of cashflows
  - **Feedback loop** between cash dynamics and corporate debt pricing
  - Lower debt prices $\Rightarrow$ smaller cashflow growth
  - Smaller cashflow growth $\Rightarrow$ lower debt prices
- The feedback loop **amplifies** the negative impact of rollover losses on expected cashflow growth
- In Diamond and He (2014): only the timing of cashflow growth is impacted by this feedback, NOT the size of cashflow growth.
- Diamond and He (2014) do NOT have amplification.

Rollover–Debt Amplification Mechanism



Diamond & He (2014)

- Much simpler cashflow dynamics

$$\frac{dX_t}{X_t} = i_t dt + \sigma dZ_t,$$

  where

$$i_t = \begin{cases} 0 & t \leq \tau \\ i & t > \tau \end{cases}$$

- Rollover – debt feedback loop only impacts investment timing, τ, not the new cashflow growth rate i, which is exogenous.

Simulation of X_t

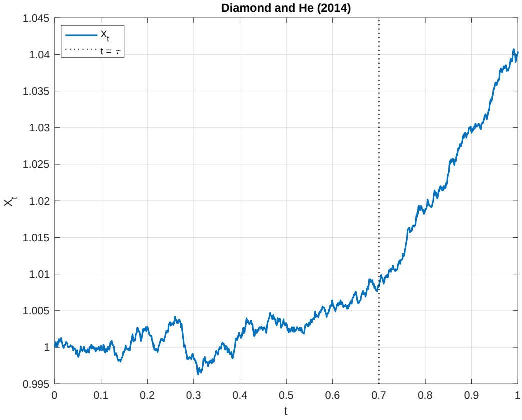


Figure: Path of X_t with drift switching at $t = \tau$.

This paper

- Endogenous cashflow growth
- Expected cashflow growth reduced by rollover losses which depend on debt prices

$$dW_t = (1-\theta)\left[K^\alpha\left(\mu dt + \sigma dZ_t\right) + Gdt\right] - L(W_t)dt$$

where

$$L(W) = \frac{1}{M}\left[P - (1-\kappa)D(W)\right]$$

- Rollover – debt feedback loop **amplifies** the negative impact of rollover losses on endogenous expected cashflow growth

Is there an Amplification Mechanism?

1. Separate out impact of potential amplification on debt price

$$D(W) = D_0(W) - \underbrace{D_1(W)}_{\text{amplification}}$$

2. Important to prove that $(\forall W > 0) D_1(W) \geq 0$
3. Why is this important?
   - if $D_1(W) = 0$, there is no amplification
   - if $D_1(W) < 0$ there is shrinkage – the impact of rollover losses is offset by an increase in debt prices

Theorem 1

Roll over losses reduce debt prices. The debt price $D(W)$ is given by

$$D(W) = D_0(W) - D_1(W),$$

where $(\forall W > 0) D_1(W) \geq 0$
A reduction in debt prices further increases rollover losses which decreases debt prices further.

$$L(W) = L_0(W) + \underbrace{L_1(W)}_{\text{amplification}}$$

where

$$L_0(W) = \frac{1}{M}[P - (1-\kappa)D_0(W)]$$
$$L_1(W) = \frac{1}{M}(1-\kappa)D_1(W)$$

and $(\forall W > 0) L_1(W) \geq 0$

Main Idea for Proof

- **Set up the difference:**

$$\Delta(W) \;=\; D(W;a) \;-\; D_0(W), \quad B_1(W) \;=\; -\frac{\Delta(W)}{a\,P}.$$

- **Observe the boundary values:**

$$\Delta(0) = 0, \qquad \lim_{W\to\infty} \Delta(W) = 0.$$

- **Derive the ODE for Δ:** $L[\Delta] = 0$.
- **Apply the maximum-principle:**
  - A twice-differentiable Δ that vanishes at both ends and satisfies $L[\Delta] > 0$ in between must be strictly negative.
- **Conclude positivity of B_1:**

$$\Delta(W) < 0 \implies B_1(W) = -\frac{\Delta(W)}{aP} > 0.$$

Existing Empirical Measure of Rollover Risk

$$\text{Rollover risk} = \underbrace{\frac{\text{Par value} - \text{Market value}}{\text{Par value}}}_{\text{Price deviation}} \underbrace{\frac{1}{\text{Maturity}}}_{\text{Inverse maturity}}.$$

- For 10% of firms rollover risk $> 1.7\%$. A signficant number when compared with cashflow growth rate.
- Quantify the importance of Amplification Mechanism for Rollover Risk by decomposing Market Value, $D(W)$: $D(W) = D_0(W) - D_1(W)$
- Only $D(W)$ is observable, so need theory for the decomposition.
- Need to find $D_0(W)$ and $D_1(W)$.
- The novel theoretical contribution now has an empirical application!

Quantifying the Amplification Mechanism

1. Separate out impact of amplification on debt price

$$D(W) = D_0(W) - \underbrace{D_1(W)}_{\text{amplification}}$$

2. Separate out impact of amplification on expected cashflow growth

$$L(W) = L_0(W) + \underbrace{L_1(W)}_{\text{amplification}}$$

where

$$L_0(W) = \frac{1}{M}[P - (1-\kappa)D_0(W)]$$
$$L_1(W) = \frac{1}{M}(1-\kappa)D_1(W)$$

3. Derive and solve ode for $D_0(W)$
4. Derive and solve ode for $D_1(W)$

Finding $D_0(W)$ – debt price without amplification I

1. Start from ode for $D(W)$

$$0 = \frac{1}{2}D''(W)E_t\left[\frac{(dW_t)^2}{dt}\right] + D'(W_t)\left[(r-\lambda)W_t - C + E_t\left[\frac{dW_t}{dt}\right]\right] - \left(r + \frac{1}{M}\right)D\left(W_t\right) + C + \frac{P}{M}$$

where

$$dW_t = (1-\theta)\left[K^{\alpha}\left(\mu dt + \sigma dZ_t\right) + Gdt\right] - L(W_t)dt$$

and

$$L(W) = \frac{1}{M}\left[P - (1-\kappa)D(W)\right]$$

Finding $D_0(W)$ – debt price without amplification II

2. $D_0(W)$ is just the debt price when there are no rollover losses.

$$0 = \frac{1}{2}\hat{\sigma}^2 D_0''(W) + (\ell W_t + \hat{\mu}) D_0(W) - \hat{r} D_0(W) + C + \frac{P}{M}$$

where

$$\begin{aligned}
\hat{\sigma} &= (1-\theta)K^\alpha \sigma \\
\hat{r} &= r + \frac{1}{M} \\
\ell &= r - \lambda \\
\hat{\mu} &= (1-\theta)(K^\alpha \mu + G) - C
\end{aligned}$$

with bc's $D_0(0) = b$, $\lim_{W\to\infty} D_0'(W) = 0$.

- Paper relies on numerical solutions. But this ode can be solved **analytically**.

Finding $D_0(W)$ – debt price without amplification III

3. Solution of ode for $D_0(W)$

Proposition 1

The debt price without amplification is given by

$$D_0(W) = \frac{C+P/M}{\hat{r}} - \overbrace{\left(\frac{C+P/M}{\hat{r}} - b\right)\exp\left(-\frac{\ell}{\hat{\sigma}^2}W^2 - \frac{\hat{\mu}}{\hat{\sigma}^2}W\right)\mathcal{D}_{-\frac{\hat{r}}{\ell}}(\zeta(W))}^{\text{impact of reduced cash}},$$

where

$$\nu = -\frac{\hat{r}}{\ell}, \quad \zeta(W) = \frac{\sqrt{2\ell}}{\hat{\sigma}}\left(W + \frac{\hat{\mu}}{\ell}\right).$$

and $\mathcal{D}_p(x)$ is a special function of mathematical physics known as Whittaker and Watson's parabolic cylinder function.

- $\mathcal{D}_p(x)$ can be expressed in terms of the confluent hypergeometric function
- Abadir (1993) provides a series expansion for $\mathcal{D}_p(x)$

Finding $D_1(W)$ – reduction in debt price due to amplification I

1. Derive ode for $D_1(W)$
2. Rewrite rollover loss in a clever way exploiting parameterization in paper

$$L(W) = \frac{1}{M}[P - (1-\kappa)D(W)] = \frac{P}{M}[1 - (1-\kappa)\frac{D(W)}{P}]$$

- Key point is that $a = \frac{P}{M} = \frac{0.75}{1.3} \approx 0.58$ is less than 1
- Enables a perturbation expansion in a.
- $D_0(W)$ is the debt price when $a = 0$.

Finding $D_1(W)$ – reduction in debt price due to amplification II

3. Write $D_1(W) = aPB_1(W)$. Derive **exact** ode for $B_1(W)$.

Proposition 2

The debt price is given by $D(W) = D_0(P) - aPB_1(W)$, where $B_1(W)$ satisfies the following ode

$$
\begin{aligned}
0 = {} & \frac{1}{2}\hat{\sigma}^2 B_1''(W) + [\ell W + \hat{\mu} - a[1 - (1-\kappa)B_0(W)]]\, B_1'(W) \\
& - \left[\hat{r} - a(1-\kappa)B_0'(W) + a^2(1-\kappa)B_1'(W)\right] B_1(W) \\
& + [1 - (1-\kappa)B_0(W)]B_0'(W),
\end{aligned}
$$

where $B_0(W) = D_0(W)/P$ and $B_1(W) = 0$, $\lim_{W\to\infty} B_0'(W) = 0$.

4. Solve above ode numerically – authors can do this easily – just use expression for $D_0(P)$ and existing numerical solution for $D(W)$.

Finding $D_1(W)$ – reduction in debt price due to amplification III

5. Find approximate solution for $B_1(W)$ by setting $a = 0$ in exact ode

$$0 = \frac{1}{2}\hat{\sigma}^2 B_1''(W) + (\ell W + \hat{\mu})\, B_1'(W) - \hat{r} B_1(W) + [1 - (1-\kappa) B_0(W)] B_0'(W),$$

where $B_0(W) = D_0(W)/P$ and $B_1(W) = 0$, $\lim_{W\to\infty} B_0'(W) = 0$.

6. We can solve the above ode analytically.

Proposition 3

The debt price is given by $D(W) = D_0(W) - aPB_1(W)$, where

$$B_1(W) = \frac{L-b}{P}\frac{\sqrt{\pi}}{\Gamma(\nu)}\exp\left(-\frac{\ell W^2 + 2\hat{\mu} W}{\hat{\sigma}^2}\right) \times \left[\mathcal{D}_{-\nu-1}(\zeta(W)) - \frac{\hat{\mu}}{\sqrt{2\ell}}\mathcal{D}_{-\nu}(\zeta(W))\right] + O(a),$$

and $L = \frac{C+P/M}{\hat{r}}$.

Conclusion

- Explain how rollover - debt feedback loop creates an amplification mechanism novel relative to Diamond and He (2014).
- Exploit existing theoretical framework to
  - Prove amplification exists
  - Decompose bond price analytically into non-amplified and amplified components: $D(W) = D_0(W) - D_1(W)$
  - Assess whether amplification is empirically relevant for rollover risk.