The Maturity Rat Race

Markus Brunnermeier, Princeton University
Martin Oehmke, Columbia University

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Is There Too Much Maturity Mismatch?

- Households have long-term saving needs
- Banks have long-term borrowing needs

⇒ Why is intermediary borrowing so short-term?

Rationale for ‘beneficial’ maturity mismatch:

- Diamond and Dybvig (1983)

There may be excessive maturity mismatch in the financial system
This Paper

A financial institution can borrow
  - from multiple creditors
  - at different maturities

Negative externality can cause excessively short-term financing:
  - shorter maturity claims dilute value of longer maturity claims
  - depending on type of interim information received at rollover dates

Externality arises
  - for any maturity structure
  - particularly during times of high volatility (crises)

Successively unravels all long-term financing: ⇒ A Maturity Rat Race
Outline

Model Setup

One Rollover Date
  ▶ Two Simple Examples
  ▶ The General Case

Multi-period Maturity Rat Race

Discussion

Related Literature
Model Setup: Long-term Project

Long-term project:

- investment at $t = 0$: $1$
- payoff at $t = T$: $\theta \sim F(\cdot)$ on $[0, \bar{\theta}]$

Over time, more information is learned:

- $s_t$ observed at $t = 1, \ldots, T - 1$
- $S_t$ is sufficient statistic for all signals up to $t$: $\theta \sim F(\cdot|S_t)$
- $S_t$ orders $F(\cdot)$ according to FOSD

Premature liquidation is costly:

- early liquidation only generates $\lambda E[\theta|S_t]$, $\lambda < 1$
Model Setup: Credit Markets

Risk-neutral, competitive lenders

All promised interest rates
- are endogenous
- depend on aggregate maturity structure

Debt contracts specifies maturity and face value:
- can match project maturity: $D_{0,T}$
- or shorter maturity $D_{0,t}$, then rollover $D_{t,t+\tau}$ etc.
- lenders make uncoordinated rollover decisions

All debt has equal priority in default:
- proportional to face value
Main Friction: Financial institution has opaque maturity structure

- simultaneously offers debt contracts to creditors
- cannot commit to aggregate maturity structure
- can commit to aggregate amount raised

An equilibrium maturity structure must satisfy two conditions:

1. Break even: all creditors must break even
2. No deviation: no incentive to change one creditor’s maturity
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Analysis with One Rollover Date

For now: focus on only one possible rollover date, $t < T$

Outline of thought experiment:

- Conjecture an equilibrium in which all debt has maturity $T$
- Calculate break-even face values
- At break-even interest rate, is there an incentive do deviate?

Denote fraction of short-term debt by $\alpha$
A Simple Example: News about Default Probability

\( \theta \) only takes two values:

- \( \theta^H \) with probability \( p \)
- \( \theta^L \) with probability \( 1 - p \)

\( p \) random, revealed at date \( t \)

If all financing has maturity \( T \):

\[
(1 - p_0) \theta^L + p_0 D_{0,T} = 1, \quad D_{0,T} = \frac{1 - (1 - p_0) \theta^L}{p_0}
\]

Break-even condition for first \( t \)-rollover creditor:

\[
(1 - p_t) \frac{D_{t,T}}{D_{0,T}} \theta^L + p_t D_{t,T} = 1, \quad D_{t,T} = \frac{1 - (1 - p_0) \theta^L}{\theta^L p_0 + (1 - \theta^L) p_t}
\]
Illustration: News about Default Probability

Deviation payoff:

$$\left. \frac{\partial \Pi}{\partial \alpha} \right|_{\alpha=0} = E[p_tD_{0,T}] - E[p_tD_{t,T}] > 0?$$

Product of two quantities matters:

- Promised face value under ST and LT debt (left)
- Probability that face value is repaid (right)
Illustration: News about Default Probability

Multiplying promised face value and repayment probability:

Note:
$A > B$ implies rolling over cheaper in expectation
A Simple Example: News about Recovery Value

$\theta$ only takes two values:

- $\theta^H$ with probability $p = 1/2$
- $\theta^L$ with probability $1 - p$

Low cash flow $\theta^L$ random, revealed at date $t$

If all financing has maturity $T$:

$$\frac{1}{2}D_{0,T} + \frac{1}{2}E[\theta^L] = 1, \quad D_{0,T} = 2 - E[\theta^L]$$

Break-even condition for first $t$-rollover creditor:

$$\frac{1}{2}D_{t,T} + \frac{1}{2}\frac{D_{t,T}}{D_{0,T}}\theta^L = 1, \quad D_{t,T}(\theta^L) = 2 \frac{2 - E[\theta^L]}{2 - E[\theta^L] + \theta^L}$$
Illustration: News about Recovery Value

Deviation payoff:

\[ \frac{\partial \Pi}{\partial \alpha} \bigg|_{\alpha=0} = \frac{1}{2} D_{0,T} - \frac{1}{2} E[D_{t,T}(\theta^L)] > 0? \]

Product of two quantities matters:

- Promised face value under ST and LT debt (left)
- Probability that face value is repaid (right)
Illustration: News about Recovery Value

Multiplying promised face value and repayment probability:

Note:

$A' < B'$ implies rolling over more expensive in expectation
Rollover face value $D_{t,T}$ (promised interest rate)

- is endogenous
- adjusts to interim information

<table>
<thead>
<tr>
<th>Interim Signal</th>
<th>$D_{t,T}$</th>
<th>default</th>
<th>no default</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>high</td>
<td>LT creditors lose</td>
<td>no effect</td>
</tr>
<tr>
<td>Positive</td>
<td>low</td>
<td>LT creditors gain</td>
<td>no effect</td>
</tr>
</tbody>
</table>

If default sufficiently more likely after negative signals
$\Rightarrow$ LT creditors lose on average
General One-Step Deviation

Extend to:

- general payoff distribution
- start from any conjectured equilibrium that involves some amount of LT debt

**Assumption 1:** \( D_{t, T} (S_t) \int_{D_T(S_t)}^\infty dF (\theta | S_t) \) is weakly increasing in \( S_t \)

- Guarantees signal has sufficient effect on default probability

**Proposition: One-step Deviation.** Under Assumption 1, the unique equilibrium is all short-term financing (\( \alpha = 1 \)).
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Many Rollover Dates: The Maturity Rat Race

Up to now: focus on one potential rollover date

➢ Assumed everyone has maturity of length $T$
➢ Showed that there is a deviation to shorten maturity to $t$

This extends to **multiple** rollover dates

➢ Assume all creditors roll over for the first time at some time $\tau < T$
➢ By same argument as before, there is an incentive to deviate
➢ In proof: For $\tau < T$ replace final payoff by **continuation value**

$\Rightarrow$ **Successive unraveling** of maturity structure
The Maturity Rat Race: Successive Unraveling
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Assumption 2: $D_{t-1,t}(S_{t-1}) \int_{S_t}^{\infty} dG(S_t|S_{t-1})$ is increasing in $S_{t-1}$ \( \forall t \)

- Guarantees signal has sufficient effect on rollover probability at next rollover date

Proposition: Sequential Unraveling. Under Assumption 2, successive application of the one-step deviation principle results in unraveling of the maturity structure to the minimum rollover interval.
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Rat Race Causes Inefficiencies

Excessive Rollover Risk

- Project could be financed without any rollover risk
- Rat race leads to positive rollover risk in equilibrium

Underinvestment

- Creditors rationally anticipate rat race
- NPV of project must outweigh eqm liquidation costs
- ⇒ some positive NPV projects don’t get financed
Rat Race Strongest During Crises

Rat race stronger when more information about default probability is released at interim dates

- ability to adjust financing terms becomes more valuable

⇒ Volatile environments, such as crises, facilitate rat race

Explains drastic shortening of unsecured credit markets in crisis

- e.g. commercial paper during fall of 2008
Seniority, Covenants

Priority for LT debt and covenants may limit rat race

Can reduce externality of ST debt on LT debt

- Seniority for LT debt
- Restrictions on raising face value of ST debt at \( t < T \)

But:

- by pulling out early, ST creditors may still have *de facto* seniority
- Particularly for financial institutions, covenants are hard to write/enforce
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‘Beneficial’ Maturity Mismatch
- Diamond and Dybvig (1983)

Papers on ‘Rollover Risk’
- Acharya, Gale and Yorulmazer (2009)
- He and Xiong (2009)
- Brunnermeier and Yogo (2009)

Signaling Models of Short-term Debt
- Flannery (1986)
- Diamond (1991)
- Stein (2005)
Equilibrium maturity structure may be efficiently short-term

- Contractual externality between ST and LT creditors
- Maturity Rat Race successively unravels long-term financing

This leads to

- too much maturity mismatch
- excessive rollover risk
- underinvestment

Not easily fixed through covenants or seniority for LT debt
Extra Slides
A Simple Example: News about Default Probability

θ only takes two values:

- \( \theta^H = 1.5 \) with probability \( p = 0.8 \)
- \( \theta^L = 0.6 \) with probability \( 1 - p = 0.2 \)

\( p \) updated at date \( t \) to \( p_t = 0.8 \pm 0.1 \)

If all financing has maturity \( T \):

\[
(1 - p_0) \theta^L + p_0 D_{0,T} = 1, \quad D_{0,T} = 1.1
\]

Break-even condition for first \( t \)-rollover creditor:

\[
(1 - p_t) \frac{D_{t,T}}{D_{0,T}} \theta^L + p_t D_{t,T} = 1, \quad D_{t,T} = \begin{cases} 
1.047 & \text{if } p_t = 0.9 \\
1.158 & \text{if } p_t = 0.7
\end{cases}
\]
Illustration: News about Default Probability

Deviation payoff:

$$\frac{\partial \Pi}{\partial \alpha} = p_0 D_{0,T} - E[p_t D_{t,T}(p_t)] > 0?$$

Product of two quantities matters:

- Promised face value under ST and LT debt
- Probability that face value is repaid

$$\frac{\partial \Pi}{\partial \alpha} = 0.8 \times 1.1 - 0.5 \times (0.9 \times 1.047) - 0.5 \times (0.7 \times 1.158) = 0.0033 > 0$$

$$\Rightarrow \text{Deviation profitable}$$
A Simple Example: News about Recovery Value

\( \theta \) only takes two values:

- \( \theta^H = 1.5 \) with probability \( p = 0.8 \)
- \( \theta^L = 0.6 \) with probability \( 1 - p = 0.2 \)

Low cash flow \( \theta^L \) random, updated at date \( t \): \( 0.6 \pm 0.1 \)

If all financing has maturity \( T \):

\[
(1 - p) E[\theta^L] + pD_{0,T} = 1, \quad D_{0,T} = 1.1
\]

Break-even condition for first \( t \)-rollover creditor:

\[
(1 - p) \frac{D_{t,T}}{D_{0,T}} \theta^L + pD_{t,T} = 1, \quad D_{t,T} = \begin{cases} 
1.078 & \text{if } \theta^L = 0.7 \\
1.112 & \text{if } \theta^L = 0.5
\end{cases}
\]
Illustration: News about Recovery Value

Deviation payoff:

\[
\frac{\partial \Pi}{\partial \alpha} = pD_{0,T} - pE[D_{t,T}(\theta^L)] > 0?
\]

Product of two quantities matters:

- Promised face value under ST and LT debt
- Probability that face value is repaid

\[
\frac{\partial \Pi}{\partial \alpha} = 0.8 \times 1.1 - 0.5 \times (0.8 \times 1.078) - 0.5 \times (0.8 \times 1.122) = -0.0003 < 0
\]

⇒ Deviation not profitable
Inefficiency 1: Excessive Rollover Risk

- Project could be financed without *any* rollover risk
- Rat race leads to *positive rollover risk* in equilibrium

⇒ Clearly inefficient

**Corollary: Excessive Rollover Risk.** The equilibrium maturity structure \( (\alpha = 1) \) exhibits excessive rollover risk when conditional on the worst interim signal the expected cash flow of the project is less than the initial investment 1, i.e. \( \int_0^\theta \theta dF \left( \theta \mid S_t^L \right) < 1. \)
Inefficiency 2: Underinvestment

Creditors rationally anticipate rat race:

- NPV of project must outweigh eqm liquidation costs
- ⇒ some positive NPV projects don’t get financed

Corollary: Some positive NPV projects will not get financed. As a result of the maturity rat race, some positive NPV projects will not get financed. To be financed in equilibrium, a project’s NPV must exceed

\[(1 - \lambda) \int_{S_t^L}^{\ddot{S}_t(1)} E [\theta|S_t] dG_t (S_t).\]